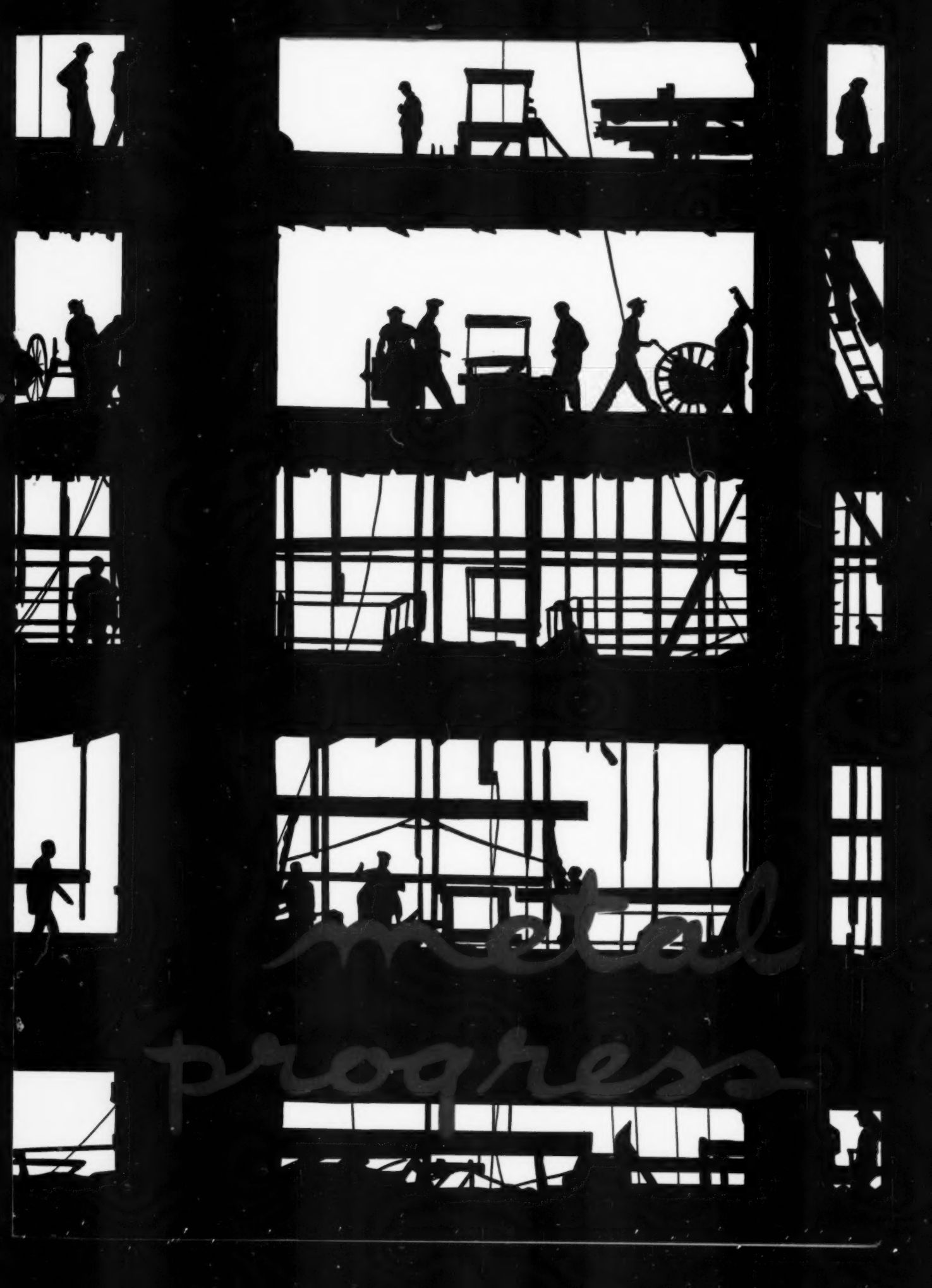
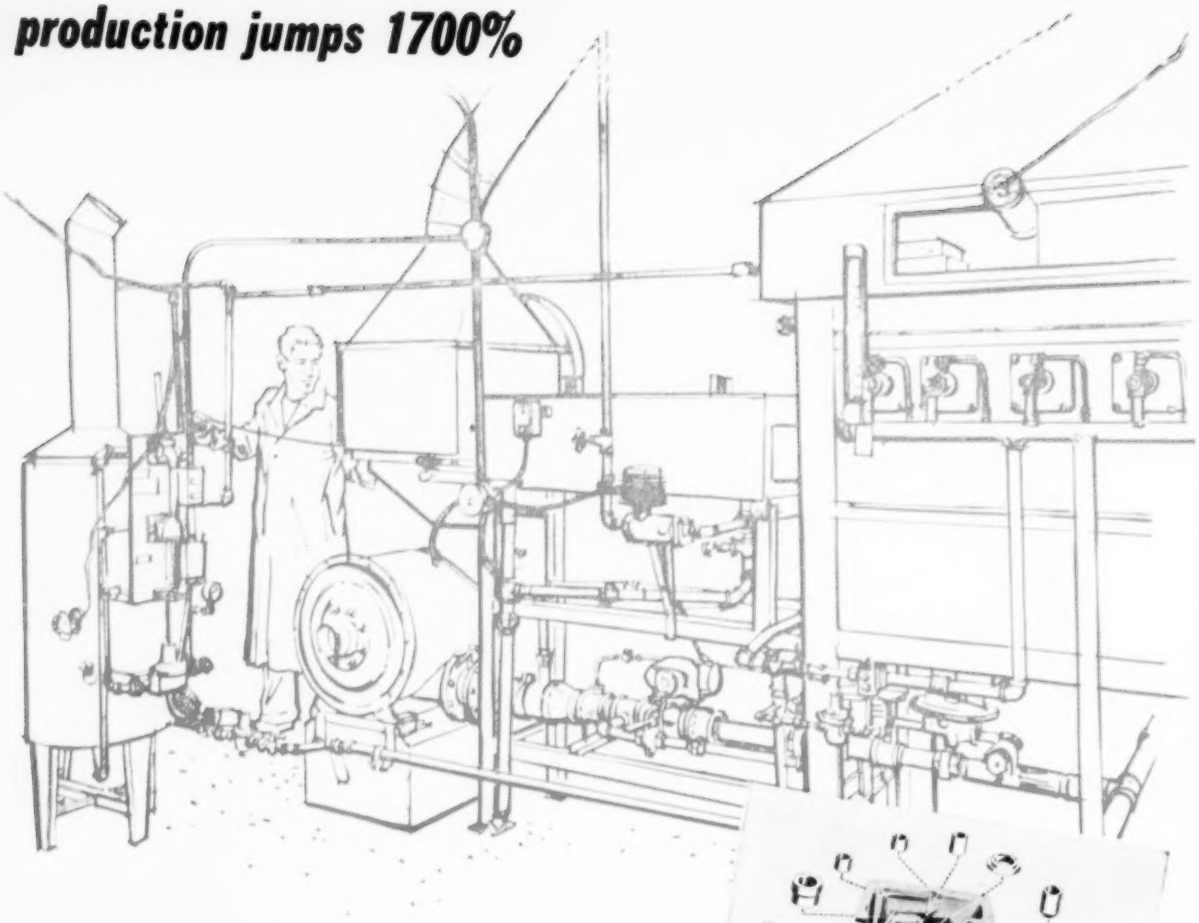
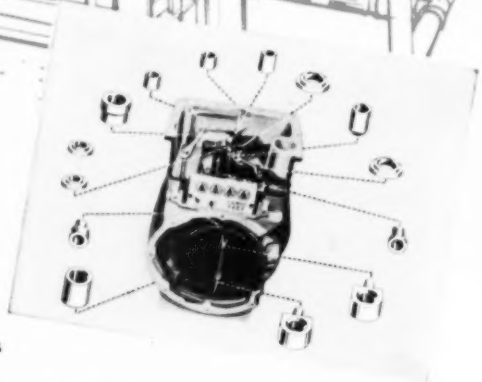

metal
progress

production jumps 1700%





in 'powder room' for metal

When the American Meter Company started sintering precision parts for their meters, their production curve shot up like a scared rocket. For example, they formerly machined one of the bushings, with a production rate of 230 pieces per hour. The same part, of sintered bronze powder, is now turned out at a rate of 4,000 per hour! That's an increase of 1700%!

Meter buyers benefit from the changeover, too. Sintered parts improve meter operation: self-lubricating, they reduce friction loss that upsets accuracy, eliminate the necessity of continual maintenance.

Heart of the sintering process at American Meter is a Surface Combustion gas-fired muffle furnace with cooling chamber. Sintering of the metal powder (90% copper, 10% tin) is done at 1550°F. A 'Surface' automatic MAX generator provides a furnace atmosphere which protects the parts from deterioration. This equipment is also used to anneal steel and brass parts when production time is available. Surface Combustion will be glad to help you examine the possibilities of powder metallurgy. Write for Literature Group H53-9.

Surface
HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING *Janitrol* AUTOMATIC SPACE HEATING

Metal Progress . . . . . June 1954, Vol. 65, No. 6

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They heat treat 50 different types of gears . . .

with one type of THERMALLOY* TRAY

Thermalloy tray and fixtures with adapter in place to give different loading pattern. Spacers at right.

A large automotive parts manufacturer processes over 50 different types of gears in a carburizing-oil quench furnace where temperatures range to 1700°F. A heat-treat tray design was needed to withstand rugged service...to give maximum loading for all gears.

Here's how Electro-Alloys developed a versatile tray to meet these conditions:

First: Electro-Alloys engineers designed a type of tray and set of fixtures to handle this wide variety of gears. This was accomplished by supplying adapters and spacers to supplement the basic tray design. With this adaptability, fewer trays were needed . . . less handling time was required in heat treating the variety of gears.

Second: Trays, fixtures, adapters, spacers . . . all were cast in Thermalloy . . . a tough heat-resistant alloy developed specifically to take heavy loads and rough usage . . . to withstand elevated temperatures up to 2100°F. without scaling or cracking. This tray takes loads up to 315 lbs. per tray . . . has been in service for over 13 months.

Electro-Alloys has helped engineer many types of heat-treat parts and has cast them in Thermalloy for longer life. Why not put this knowledge to work for you . . . call your nearest Electro-Alloys office or write Electro-Alloys Division, 5002 Taylor Street, Elyria, Ohio, for a copy of Thermalloy Tray & Fixture Bulletin T-227.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION

Elyria, Ohio

*Reg. U. S. Pat. Off.

As I was saying...

WE ALL like to hear nice words said about the activities and results of the operations with which we are associated. I'm glad I'm just like all the rest of you with the olfactory sense still sensitive and enjoying the fragrance. And what was it that set me up? Well, here are "them words":

"Informed by several of our associates concerned with shell molding that this article in *Metal Progress* was one of the best released up to this time" . . . Another: "reader since high school days and consider *Metal Progress* to be the most interesting and most widely read publication in the metals field" . . . More of the same: "standard of accuracy of MP resembles that of proceedings of the technical societies rather than casual regard for facts that is so characteristic today" . . . On another track: "and to the art director of MP, congratulations on the fine covers. We know of no other technical or trade publication that does a comparable job or even seems aware of the fact that metallurgists, engineers and other technical men possess considerably more esthetic perspective than the general public" . . .

And now a message from the *Library Journal* that "Behavior of Metals at Low Temperatures" and "Zirconium and Zirconium Alloys" (A.S.M. books published last year) have been selected by an award committee as two of the "Best 100 Technical Books Published in 1953". Congratulations to the authors of the papers in those volumes.

The 50 ⓢ scholarships awarded by the Foundation bring heaps of praise and thanks from all concerned; i.e., "In acknowledging receipt I would like to express appreciation of the entire faculty for this award. I would like to add also we here all realize that while many of the technical societies have been talking about the various educational problems they might tackle the A.S.M. has actively been doing something constructive about the situation."

Not to use too many quotes, you recall the fine things you have heard about the Metal Congress, the Coffee Breaks, the Metal Exposition, the Western Metal Congress and Exposition, *Transactions* (just mailed), *Metals Review*, the "Review of Current Metal Literature," Metals Handbook, (the awaited First Supplement to appear in midsummer in *Metal Progress*), the A.S.M. Metallurgical Teaching Awards, the A.S.M. Visiting Lectureships, the A.S.M. Science Achievement Awards, the A.S.M. Science Teachers Recognition Awards, the A.S.M. Vocational Teachers Training Program to be conducted this summer in New York, Massachusetts, Connecticut, Pennsylvania, Michigan and Illinois, the Student Employment Service, and the fact that A.S.M. is the largest publisher in the world (that's lots of territory) of books for the metal industry – and all on dues of only $10 per year. And we are all pleased to hear one more interesting fact – that the members' dues have not been increased since the founding of the Society some 36 years ago.

You surely are entitled to that feeling of pride when you survey what you members have accomplished. These services will continue long into the future. But one cannot stand still and yet grow.

So the events above, important as they are, are only the beginning.

An envisioned program of advancing progress and expansion for A.S.M. should now command the serious thought and attention of all members. The great future of the Society may well be planned now with many ambitious goals set so high that their attainment will require the same concentrated cooperation and response of all members in the years to come as in the past.

Cordially yours,

Bill

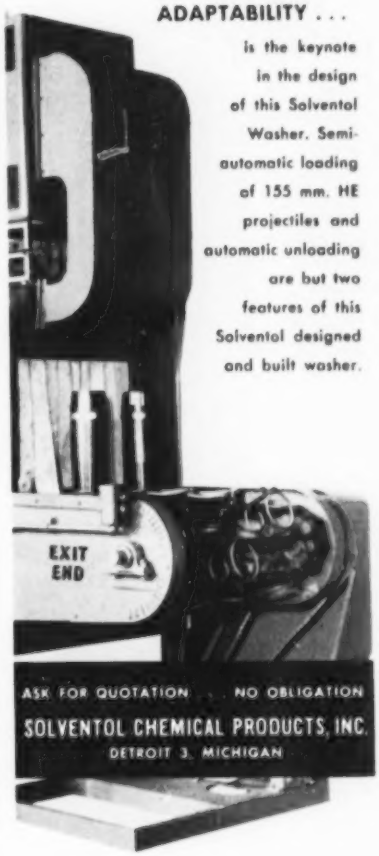
W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

Solventol
DI-PHASE
METAL CLEANING

Removes more types of soil from more kinds of metals than is possible with other cleaning materials . . .

ASK US TO PROVE IT!

"Automation"
ADAPTABILITY . . .
is the keynote in the design of this Solventol Washer. Semi-automatic loading of 155 mm. HE projectiles and automatic unloading are but two features of this Solventol designed and built washer.

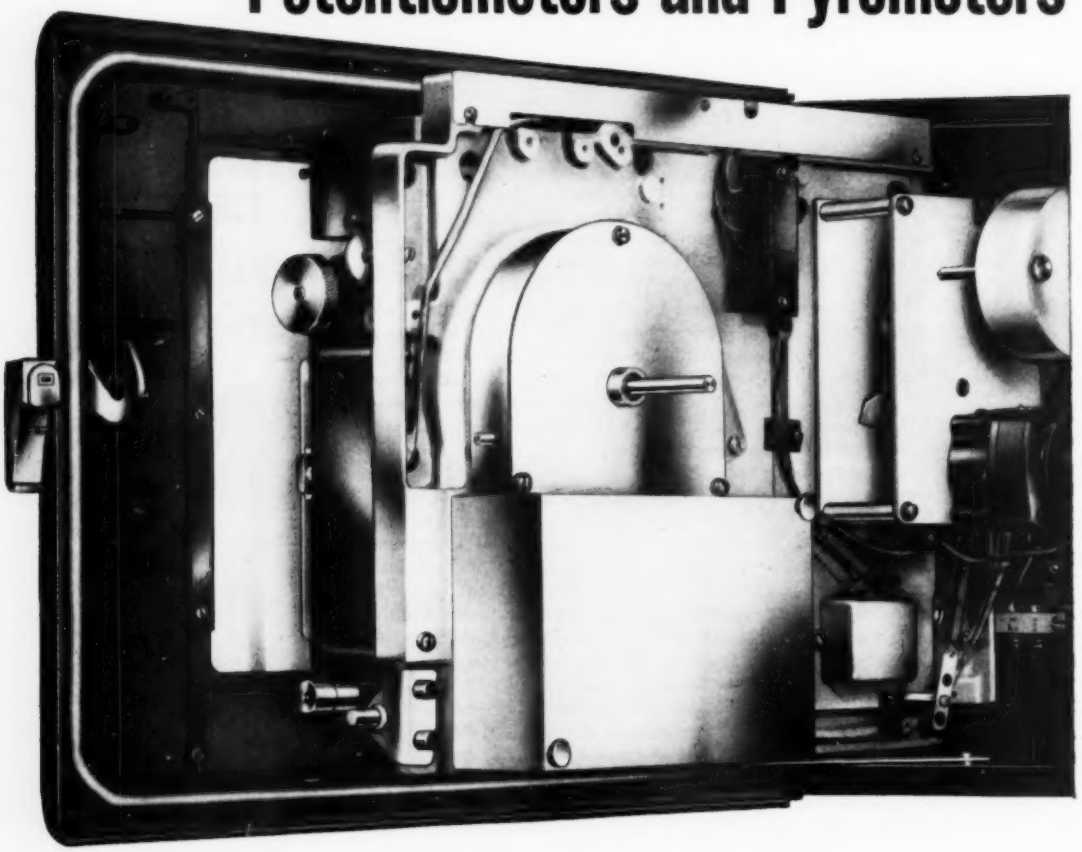


ASK FOR QUOTATION . . . NO OBLIGATION
SOLVENTOL CHEMICAL PRODUCTS, INC.
DETROIT 3, MICHIGAN

WHAT'S NEW AT BRISTOL . . . . WHAT'S NEW AT BRISTOL . . . .

CONTINUOUS STANDARDIZATION

...in Bristol Electronic Dynamaster Potentiometers and Pyrometers



LOOK FOR OUTSTANDING NEW DEVELOPMENTS FROM BRISTOL

BRISTOL

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

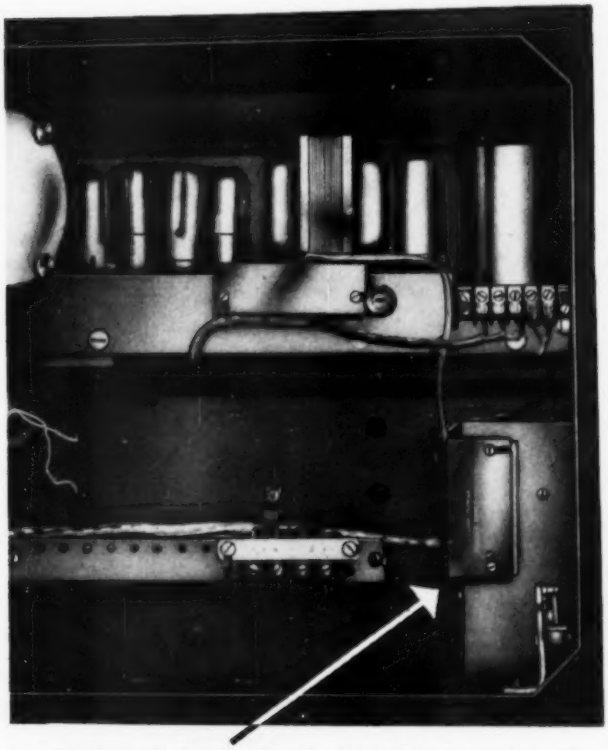
WHAT'S NEW AT BRISTOL . . . . WHAT'S NEW AT BRISTOL

with no dry cells

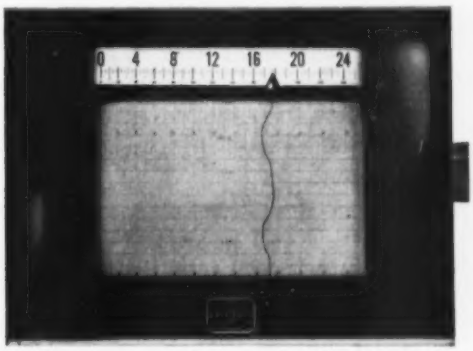
• **CONTINUOUS STANDARDIZATION** eliminates need for dry cells—supplies voltage that is continuously compared with standard cell.

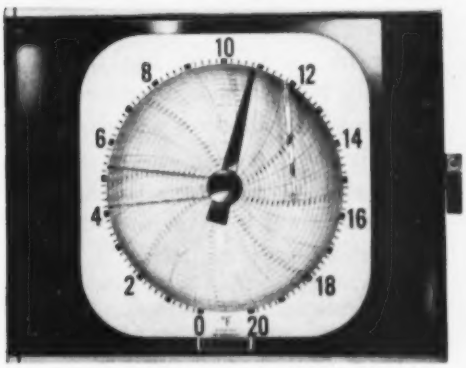
• **CONTINUOUS OPERATION—NO TIME OUT.** With continuous standardization, the potentiometer is free to continuously measure, record, and control. No time out or interruption is required for periodic standardization.

• **NO STANDARDIZING MECHANISM:** Continuous standardization is taken care of electrically. The absence of a standardizing mechanism simplifies the instrument considerably.



Continuous Standardization Unit: Eliminates dry cell—no interruptions in the operation of the potentiometer for standardization—no standardizing mechanism.





Bristol Electronic Dynamasters are made in round- and strip-chart, single- and multiple-record recorders, air-operated and electric controllers (all types of control actions). Two-pen and Program Control.

For the complete story on the modern Bristol Dynamaster, write for free 35-page booklet P1245. The Bristol Company, 106 Bristol Road, Waterbury 20, Conn.

THE DEPENDABLE GUIDEPOST OF INDUSTRY

3.17

There's a reason . . .

Look at the nameplates on the instruments in your plant . . . and in any other plant you may happen to visit. Chances are you'll find a large percentage of them bear the *ElectroniK* name. For the fact of the matter is that literally thousands of different industrial plants have purchased a total of more than eighty thousand of these instruments in the past fourteen years.

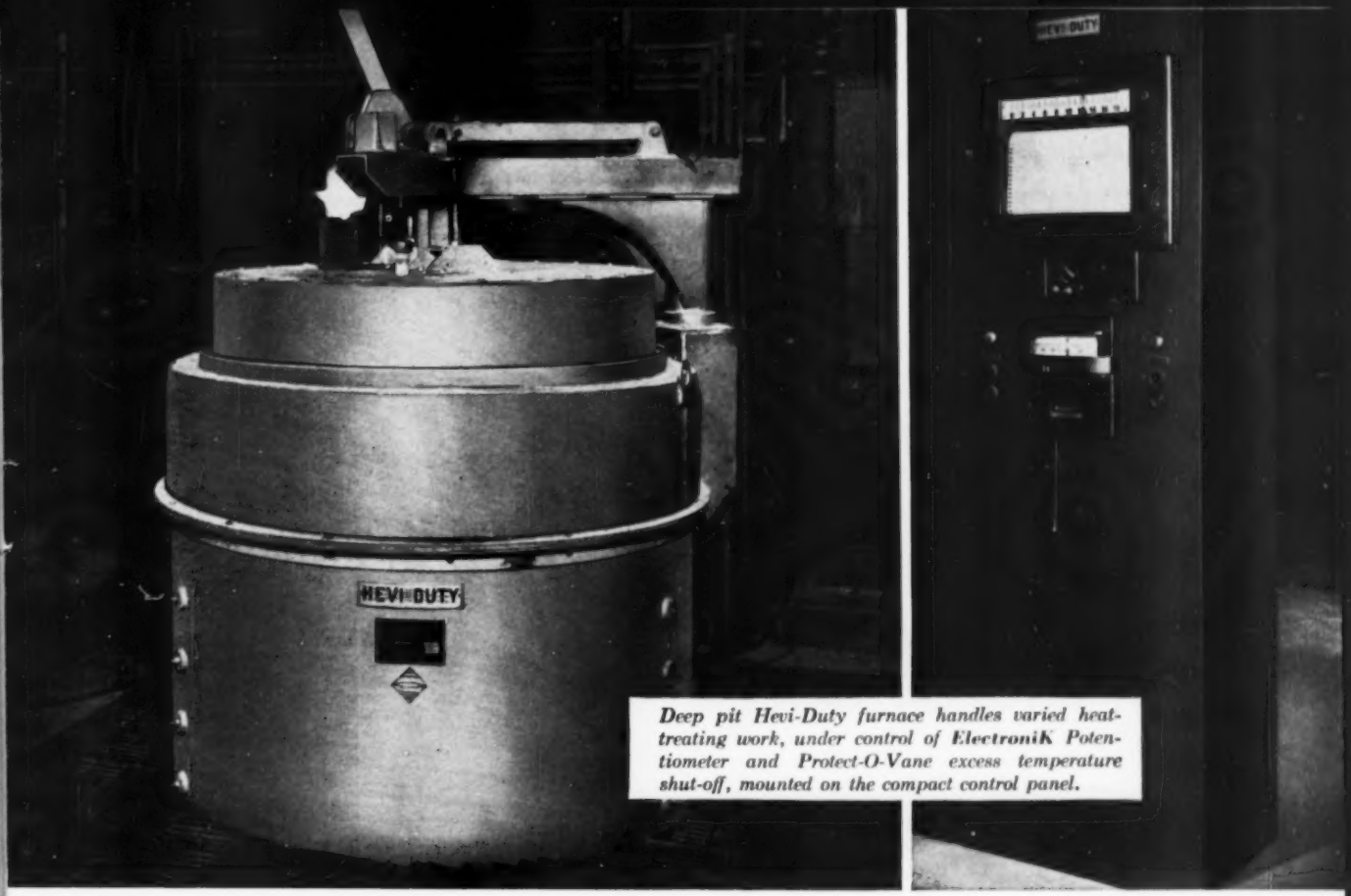
The list of companies who have chosen *ElectroniK* instruments reads like the "Who's Who" of industry. It includes leading manufacturers, large and small alike who have ordered and reordered *ElectroniK* instruments for all types of measuring, recording and controlling assignments.

This widespread acceptance didn't just happen. Some of it is doubtless due to the fact that this was the pioneer electronically operated instrument available to industry on a practical, economical basis. And because it was . . . and is . . . the leader in its field, it has behind it a uniquely broad background of development and application experience. Men in production, engineering, maintenance and research have come to know what this instrument can do, and to rely on it in the most exacting jobs.

Equally important is the excellent record which *ElectroniK* instruments have earned for themselves. They have proved their performance, in sensitivity and precision that set the standard of industry. Their versatility has opened the way to better measurement and control of temperature, flow, pH and dozens of other variables. And their simple, rugged construction has reduced maintenance to a minimum . . . and set records of dependable service under the toughest and dirtiest factory conditions.

Versatility for commercial heat-treating . . . in *ElectroniK*

Catalog 54-1 is a handy reference . . . lists specifications and prices for all ElectroniK control instruments, Pyr-O-Vane millivoltmeter pyrometers, Brown thermometers, and associated safety equipment, valves and accessories. Write for your copy today.



Deep pit Hevi-Duty furnace handles varied heat-treating work, under control of ElectroniK Potentiometer and Protect-O-Vane excess temperature shut-off, mounted on the compact control panel.

controlled Hevi-Duty furnaces

WHEN every heat-treating job is different—as it is at the California-Doran Heat Treating Company—versatility of equipment really pays dividends. To get the flexibility and accuracy they need for handling diversified production, this big Los Angeles commercial heat-treating firm uses Hevi-Duty furnaces equipped with *ElectroniK* control.

The furnace is a deep pit type which can be used for any temperature from 250 to 1850° F., for tempering, annealing and hardening. And the *ElectroniK* control system which regulates it has ample flexibility to give close temperature tolerances over this entire range. The instrument's *Electr-O-Pulse* control relay provides accurate proportional control of heating power. It switches full input alternately on and off in pulses of variable length, to adjust average power exactly to the value required to hold temperature at the set point . . . for any furnace load, large or small.

ElectroniK controllers are the ideal partner of good furnaces. By the thousands, they have proved their ability to meet the most stringent heat-treating specifications. Be sure to specify them on your new furnaces. Call on your nearby Honeywell sales engineer for a discussion of your own requirements . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

• **REFERENCE DATA: Write for new Furnace and Oven Catalog No. 54-1**

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

Since 1935 Lindberg Engineering Company has been a leader in metallurgical research and the development of industrial heating equipment.

To 500 VIP's in

Lawrence Remiker

We're not barring any readers, but this advertisement is pointed at just key men . . . top management, manufacturing superintendents, chief engineers . . . or any other VIP's who right today are making a decision to improve their industrial heating processes.

For them, Lindberg now offers a complete planning, designing and installation service through its new Field-erected Equipment Division.

R. A. Hastings

For some time, under certain conditions, Lindberg has been able to provide this service. Now, with added facilities, its established industrial heating know-how can start right in helping to answer over-all production problems in many manufacturing fields.

Headed by Lawrence Remiker and including R. A. Hastings, Elmer B. Jones and C. F. Masure, a management staff of long experience has been assembled. With enlarged plant capacity, this division is organized to

LINDBERG

American Industry

provide a higher degree of service than has ever before been available in this field.

Elmer B. Jones

For example, Field Engineers in 21 Lindberg offices throughout the country will give every contract on-the-spot service from planning right through installation. No remote control.

All fabrication will be done in Lindberg's own plants, a one-package operation that eliminates slow and costly dependence on outside suppliers.

C. F. Masure

Lindberg's large technical staff, its scientific laboratories, its years of experience in advanced metallurgical research provide the best possible background for a complete and satisfactory answer to any industrial heating problem.

If you are one of those 500 VIP's faced with such a problem Lindberg is the best source for reliable and constructive advice. Call your nearest Lindberg field office and one of our engineers will be on the job at once.

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Colorado:	Denver
Georgia:	Atlanta
Illinois:	Chicago
Indiana:	Indianapolis
Massachusetts:	Springfield
Michigan:	Detroit Kalamazoo
Missouri:	Kansas City St. Louis
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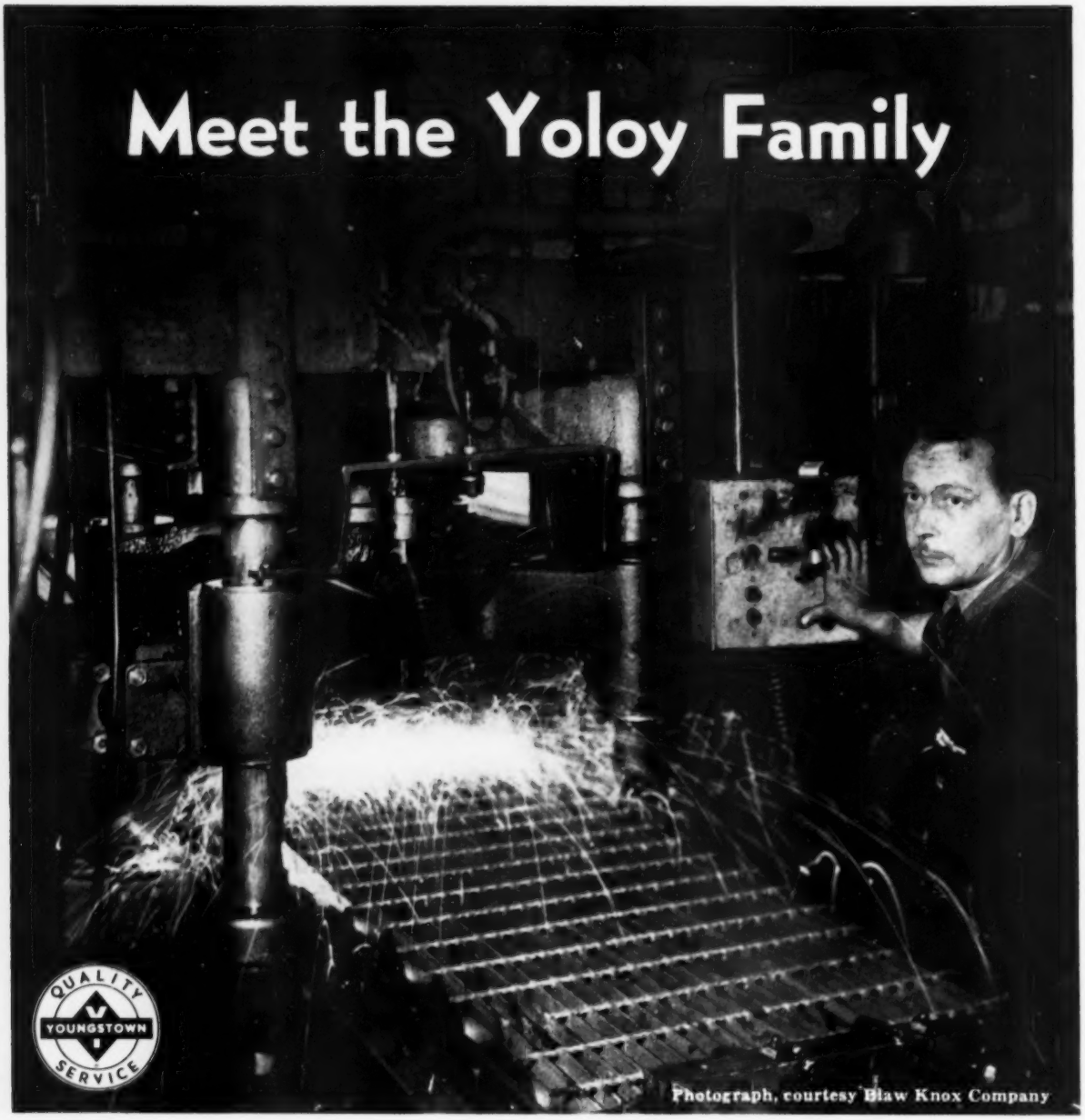
ENGINEERING COMPANY

FIELD-ERECTED EQUIPMENT DIVISION

Chicago Plant: 2448 West Hubbard Street • Chicago 12, Illinois

Los Angeles Plant: 11937 So. Regentview Avenue • at Downey, California

Meet the Yoloy Family



Photograph, courtesy Blaw Knox Company

●The Yoloy Family of steels are available to fabricators and users who require a steel that's high in resistance to corrosion, shock, vibration and is easy to fabricate and weld. The illustration shows fabrication of "Electro-forged"* grating, using Yoloy E steels, where long life and safety require superior properties. Phone or write our nearest District Sales Office for further information.

*Registered—Blaw Knox Company

Youngstown

YOLOY *(Nickel-Copper)* Low Alloy High Strength Steel

YOLOY E *(Nickel-Chrome-Copper)* Low Alloy High Strength Steel

YOLOY C *(Chrome-Copper)* Corrosion Resistant Steel

THE YOUNGSTOWN SHEET AND TUBE COMPANY *Manufacturers of Carbon, Alloy and Yoloy Steel*

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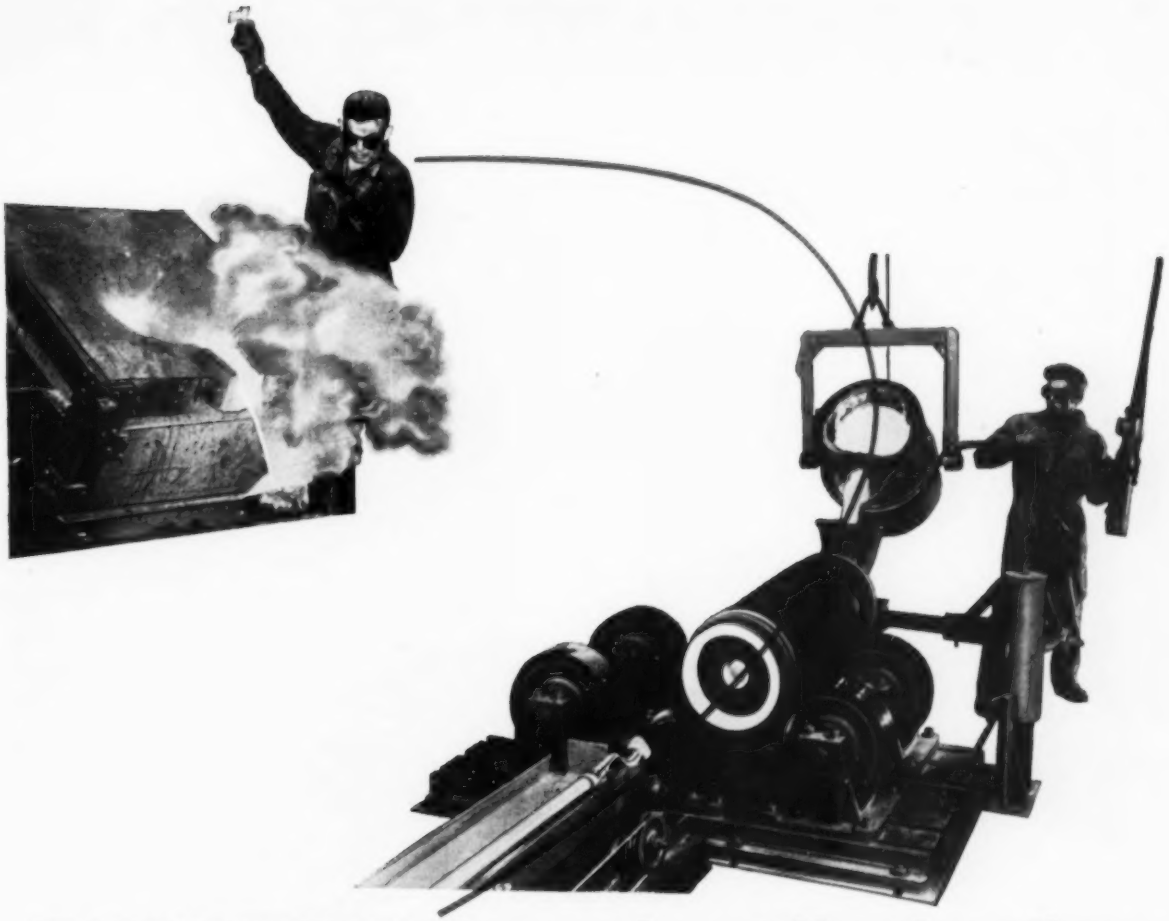


STARTING POINT for good centrifugal castings

All good casting starts in the melt with more accurate control of temperature and closer control of chemical composition. These are both *inherent advantages* of Ajax-Northrup High Frequency, Hi-Speed Induction Furnaces.

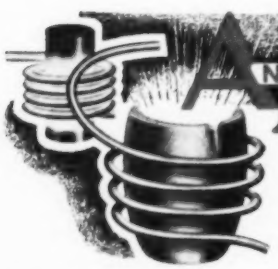
Accurate analysis is simply achieved and continuously maintained by fast melting . . . with practically no chance for oxidation. Alloying is easy because losses are negligible . . . you get out what you put in. And, even with elements of widely dissimilar densities, you pour metal of uniform composition since the melt is constantly, thoroughly stirred by electromagnetic action inherent to the furnace principle.

In actual production with an Ajax-Northrup Furnace, alloying elements can be controlled usually within 0.25%; carbon within 0.01 or 0.02%. Melts can be reproduced . . . each time with identical composition . . . or alloys may be varied quickly. Pouring temperature, especially important in centrifugal and precision casting, may be maintained exactly as desired.

Practical savings with Ajax-Northrup Hi-Speed Melting are found in the almost complete recovery of alloying elements. Savings are also realized in an overall reduction in rejects and subsequent grinding operations.

TECHNICAL DATA AVAILABLE: Tell us what you're melting . . . and in what quantities. We'll send you the proper bulletins.

543



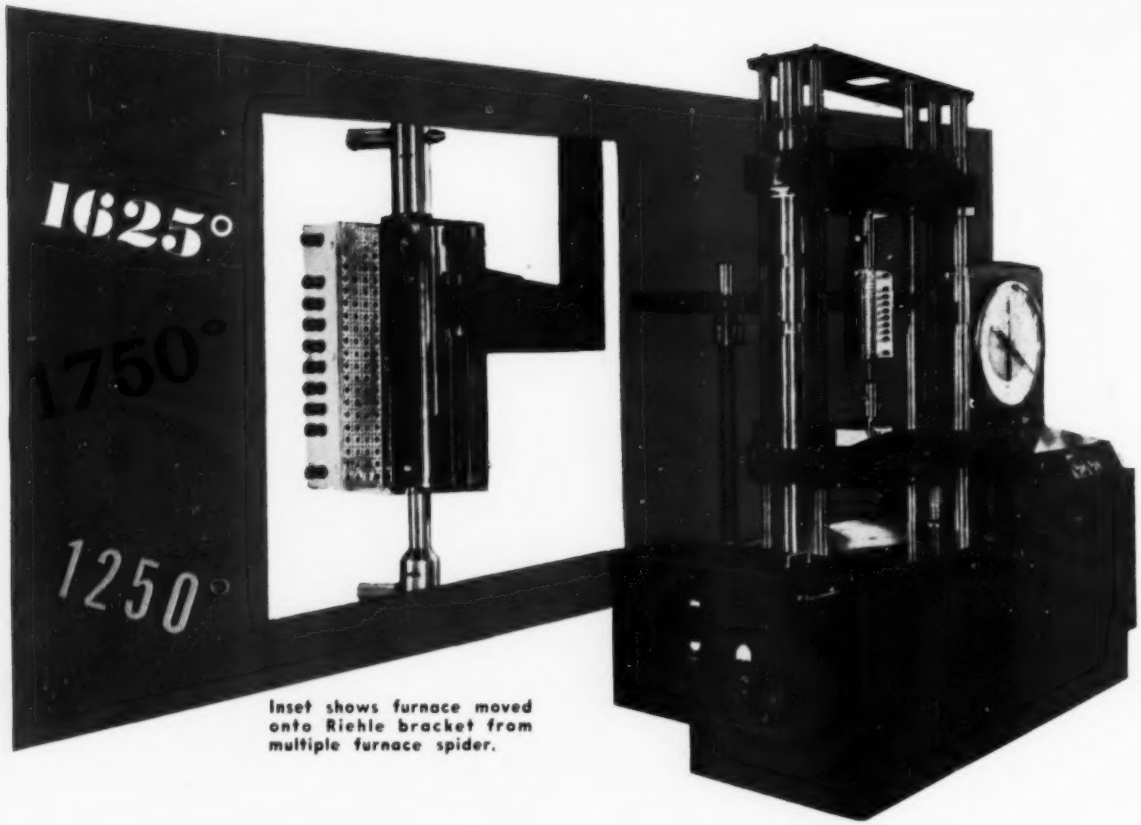
AJAX NORTHRUP SINCE 1916

INDUCTION HEATING-MELTING

AJAX ELECTROTHERMIC CORPORATION • AJAX PARK, TRENTON 5, NEW JERSEY

Associated Companies: Ajax Electrometallurgical Corp. • Ajax Electric Furnace Co. • Ajax Electric Company, Inc. • Ajax Engineering Corp.

THE HEAT'S ON



Inset shows furnace moved onto Riehle bracket from multiple furnace spider.

FOR HIGH TEMPERATURE TESTING

In many industries today, the search is for materials that will stand up under higher and higher temperatures.

If you want to predetermine the reaction of metal alloys during forming operations and in use at high temperatures, Riehle Screw Power Testing Machines will furnish the answers. Electric furnaces that heat specimens up to 1750° F. can be utilized. And, as many as 6 furnaces can be installed on one Riehle machine to speed up production testing.

This Riehle screw power machine assures positive control of testing speed. It is equipped with a self-compensating drive so the rate of strain can be maintained regardless of increases in load.

Riehle's 5-scale range feature ideally provides the coverage necessary to test specimens at elevated temperatures. Simplified specimen holders facilitate quick connection of the specimen after it is brought up to temperature.

For further details about high temperature testing with Riehle machines, mail coupon.

RIEHLE

TESTING MACHINES

Division of American Machine and Metals, Inc.
East Moline, Illinois

"One test is worth a thousand expert opinions"

See Riehle Machines

RIEHLE TESTING MACHINES
Division of American Machine and Metals, Inc.
Dept. MP-654, East Moline, Illinois

Please send details on Riehle machines for high temperature testing.

COMPANY

ADDRESS

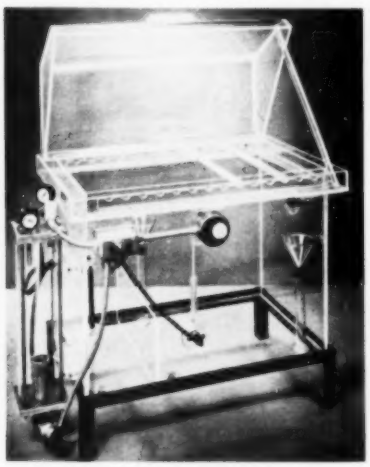
CITY ZONE STATE

NAME AND TITLE

engineering digest OF NEW PRODUCTS

Salt Spray Test Cabinet

A new salt spray test cabinet has been introduced by the G. S. Equipment Co. to meet A.S.T.M. Specification B-117-49T and Government specifications for similar equipment. No parts susceptible to corrosion are exposed to test solutions or vapors. All gages and other metal parts are on the outside. Completely transparent, the cabinet affords clear visibility for observing and controlling progress of tests, and examining specimens from all sides without opening the lid.



For further information circle No. 1509 on literature request card on p. 36-B.

Free Machining Die Steels

Latrobe Steel Co. has announced that free-machining properties have been extended to its entire line of high-carbon high-chromium die steels. The improvement in machinability has no effect on other physical properties of these steels, nor do they require any change in heat treatment. Machining time is cut as much as 50%.

For further information circle No. 1510 on literature request card on p. 36-B.

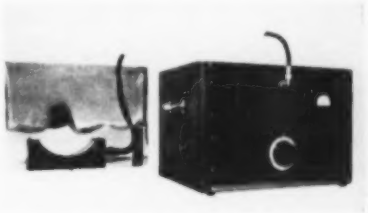
Shell Molding

Two new silicone release agents have been announced by Dow Corning Corp. for shell molders who wish to use solvent-type agents. They contain 5 and 50% solids, respectively, of high viscosity silicone fluids in mineral spirits. Designed especially for use on deep draw, narrow draft patterns, these new silicone parting agents leave minimum build-up, ease pattern cleaning, and provide multiple releases. A single application will release up to 15 shells. One preparation is designed for immediate use, the other for those who may wish to make up concentrations to met their own specific operating requirements.

For further information circle No. 1511 on literature request card on p. 36-B.

Ultrasonic Cleaning

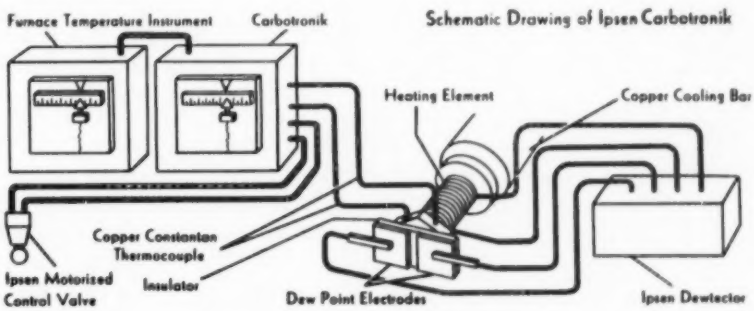
The new Sonogen ultrasonic power generator, manufactured by Branson Instruments, Inc., is designed primarily for accelerating the cleaning and degreasing of small parts and metal objects such as strip, wire and tubing, as well as complex components. It functions by activation of the cleaning solvent in which is immersed the low-voltage focused ceramic transducer. This transducer converts r.f. power to high frequency mechanical vibrations which are transmitted



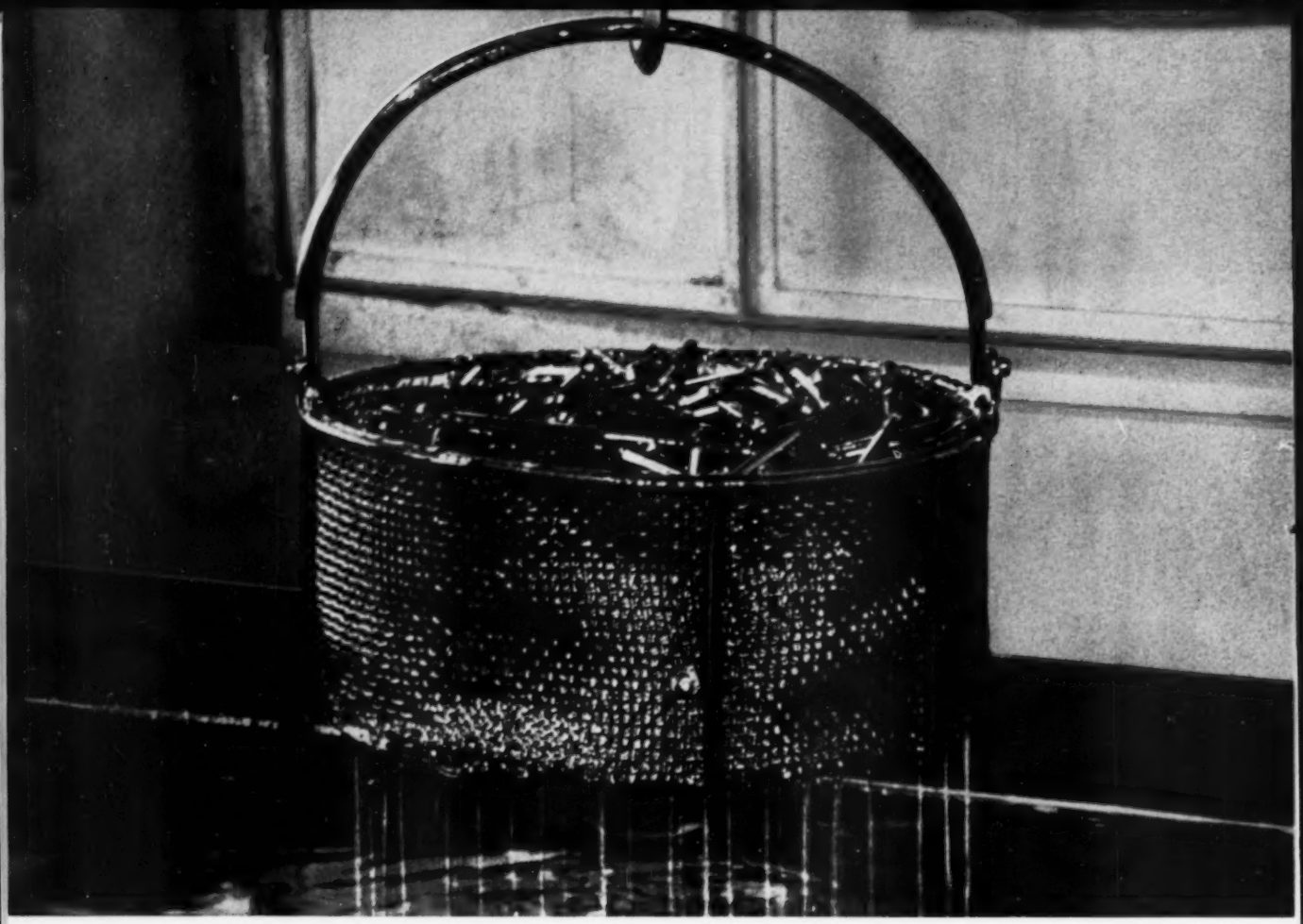
Continuous Control of Carbon Potential of Atmospheres

A new instrument, designed and manufactured by Ipsen Industries, Inc., now provides an accurate and continuous method of automatically controlling the carbon potential of endothermic furnace atmospheres. Named the Carbotronik, the new unit eliminates guess work when adding carburizing gas, and can be profitably applied to a wide variety of heat treating operations, including carburizing, carbonitriding, carbon restoration, annealing, normalizing as well as hardening.

Functioning electronically, the unit continuously indicates, records, and controls furnace atmosphere carbon potential according to a setting selected on the instrument panel. With endothermic atmospheres the carburizing potential is a function of furnace dew point and temperature. The new Ipsen instrument couples the dew point control instrument with the furnace temperature control, thus automatically correcting for temperature variables. The dew point controller, when used in this system, is graduated in terms of carburizing potential on a logarithmic scale from 0.10 to 1.25% carbon, rather than as dew point temperature. Control of the carburizing potential of the furnace atmosphere is achieved by using the instrument to throttle the flow of raw natural gas being added to the furnace atmosphere. It can be used with most controlled atmosphere furnaces.



For further information circle No. 1512 on literature request card on p. 36-B.



You Get Minimum Drag-out with Sun Quenching Oil Light

When you reduce oil consumption by lowering drag-out, you cut a major cost in operating a quenching system. Sun Quenching Oil Light thins out when heated, drains off parts faster and more completely. And Sun Quenching Oil Light, because of its natural detergency, prevents the formation of sludge deposits, aids in removing any deposits that have accumulated. And under normal operating conditions it need never be replaced. Sun's booklet "Sun Quenching Oils" tells about this low-cost oil. For a copy, call your nearest Sun office or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-6.

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

SUNOCO

PHILADELPHIA 3, PA. • SUN OIL COMPANY LTD., TORONTO & MONTREAL

Made by the producers of famous Blue Sunoco Gasoline and Dynalube Motor Oils

through the solvent to shake dirt and grease loose.

For further information circle No. 1513 on literature request card on p. 36-B.

Hardfacing

A new metal spray unit for applying hard-facing coatings in powder form has been announced by Wall Colmonoy Corp. The unit is particularly adapted to the application of nickel-base wear and corrosion-resistant hardfacing alloys to steel, stainless steel and some cast iron and copper alloy parts. In this process, the powdered alloys are first applied by spraying and then fusion-bonded to the part by heating

with an oxyacetylene flame. The Spraywelder components comprise a light weight 3-lb. aluminum pistol, a chromium-plated copper hopper, a cast brass carburetor, an air regulator, an air filter and suitable oxygen, acetylene and powder hoses and fittings. Metallizing operations using copper, nickel, stainless steel, brass, lead and zinc in powder form can also be handled.

For further information circle No. 1514 on literature request card on p. 36-B.

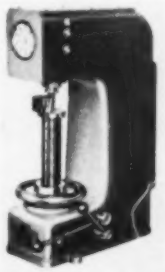
Tumbling Barrel

A new bench-type, variable-speed tumbling barrel has been announced by the Henderson Brothers Co. While the barrel is running, it can be filled with parts or abrasive, or emptied, by tilting to pouring position; work can be watched and samples removed for inspection; the angle can be changed for best abrasive or polishing action; and the running speed can be adjusted over an average range of 10 to 40 r.p.m. Barrels are made in various sizes, shapes and materials.

For further information circle No. 1515 on literature request card on p. 36-B.

Rockwell Hardness

Gries Industries, Inc., has announced an improved Wolpert-Gries Rockwell hardness testing machine. This machine can perform 400 tests per hour. The 10 kg. minor load is produced by gravity instead of by spring pressure. After the minor load is applied, no setting is required to make the dial indicator stand automatically at zero. Without removing his hand from the spindle wheel, the operator can release the oil brake, applying the major load through the weight block suspended on the loading lever. Depth indication begins at once. When the dial pointer has almost stopped, another lever removes the major load while the minor load remains. The final test result then appears.



For further information circle No. 1516 on literature request card on p. 36-B.

Composite Metal Strip

By applying production skills developed from rolling of metals for the jewelry industry, American Silver Co.'s Industrial Div. has become a producer of clad metals. Composite metal combinations are available, overlaid on one or both sides, in inlay form and edge clad. They are custom-rolled in strip up to 4 in. wide, in total overall thicknesses down to 0.001 in., with cladding down to 0.00001 in. Clad combinations include phosphor bronze on copper, copper on steel, nickel on steel, silver on beryllium copper, silver on copper, gold on nickel, silver on phosphor bronze, palladium on silver and platinum on silver.

For further information circle No. 1517 on literature request card on p. 36-B.

Hardening Furnace

The Industrial Heating Equipment Co. has announced a new semi-continuous clean hardening furnace with a capacity of 150 lb. per hour. The furnace is radiant tube gas fired, and includes a built-in generator, quench

HIGH AND LOW TEMPERATURES

NEW BENCH-TYPE TEST UNIT

WEBBER

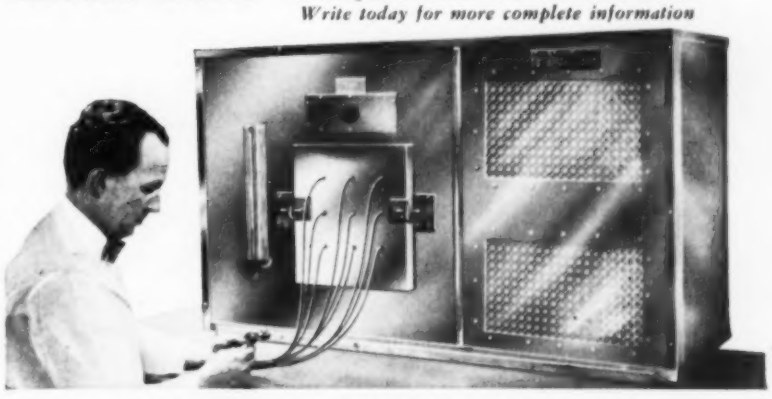
TRADE MARK REGISTERED

COMPLETE TEMPERATURE RANGE

TESTING UNITS

Combine high and low temperatures within the same cabinet with all controls self contained. Unit measures 50"x28"x20" with a testing chamber 12"x12"x12". Temperature range is from -80° F., to 185° F. Heat application is accomplished with reverse cycle refrigeration, which eliminates the hazards associated with open heating elements. A blower is provided for even distribution of temperatures and greater testing accuracy. Latch-type or hinge-type door optional. Accelerated pull-down to -80° in 30 minutes or less.

Write today for more complete information



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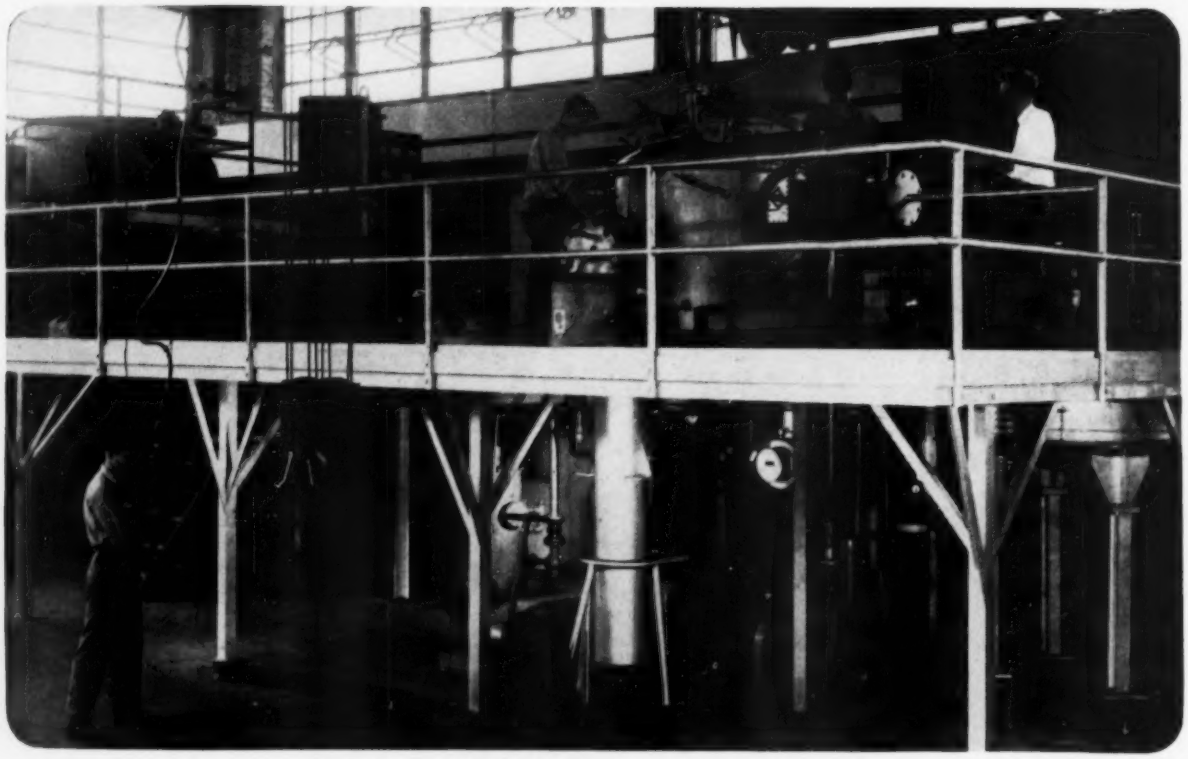
VACUUM-MELTED METALS and ALLOYS



One of Vacuum Metals Corporation vacuum furnaces in operation

VACUUM-MELTED METALS CAN HELP YOU SOLVE PROBLEMS DEMANDING:

- ★ **greater impact or fatigue strength**
- ★ **better high temperature-strength properties**
- ★ **better machinability or easier fabrication**
- ★ **cleaner, high-polish surface finish**
- ★ **improved behavior in vacuum tubes**

Interest is constantly mounting among metallurgists and design engineers about the improved properties, needed under critical operating conditions, that vacuum-melting gives to metals and alloys. Vacuum Metals Corporation offers you the results of ten years' work in this field which is developing rapidly. Write today for information concerning your particular metals applications.

THESE VACUUM-MELTED METALS NOW AVAILABLE FROM VACUUM METALS CORPORATION:

BEARING STEELS — Cleanliness and freedom from gas result in fewer rejects . . . greater production output. Field tests indicate life of bearing balls increased up to 300%.

HIGH TEMPERATURE ALLOYS — Improved high temperature properties and increased ease of fabrication.

ELECTRONIC TUBE METALS — High purity nickel, copper, iron. Tests indicate substantial increase in manufacturing output of electronic tubes using these metals in pure form or as dilute alloys.

HIGH STRENGTH ALLOY STEELS — Clean, low gas content for applications where high impact and fatigue strength and superior surface finish are required.

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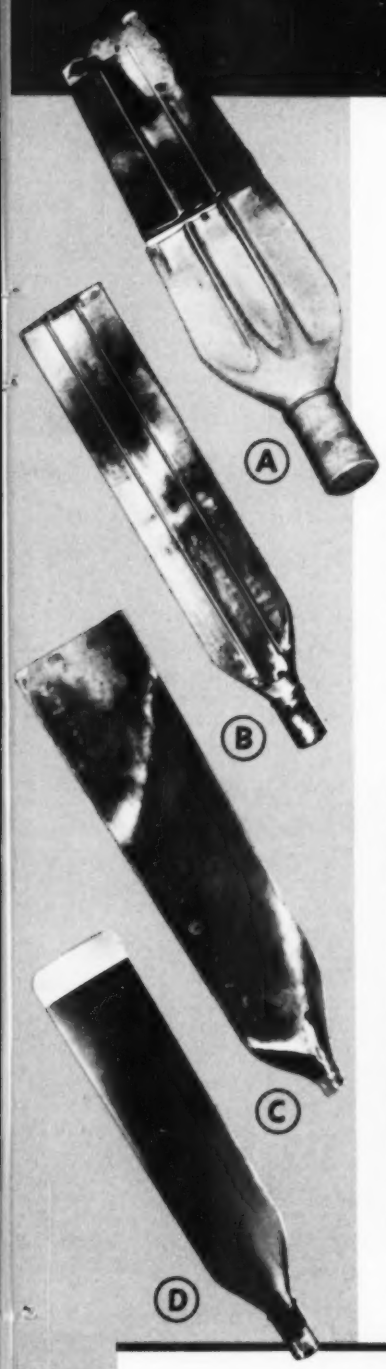
New facts for your file on

USS CARILLOY STEELS



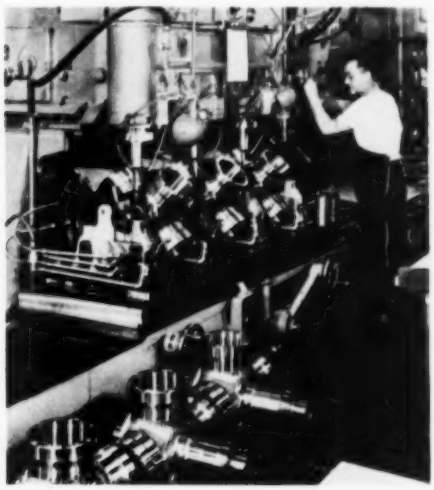
USS Carilloy steel passes rigid tests for propeller blades

● An important manufacturer of propellers for military aircraft has found that in stringent magnaflux tests, USS CARILLOY steel performs completely satisfactorily.

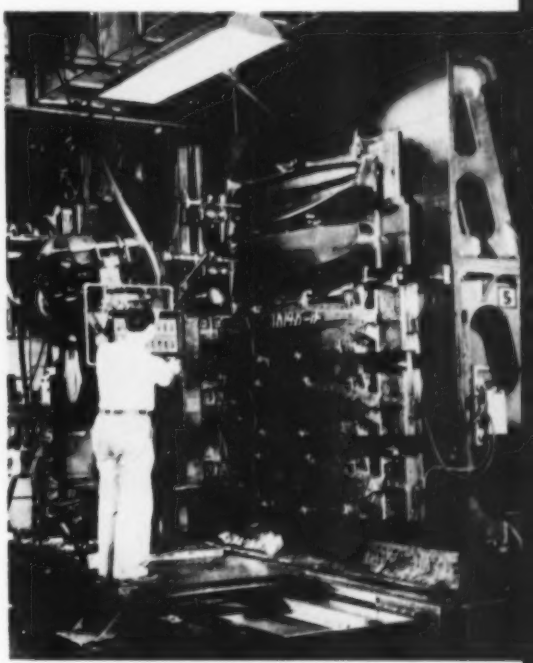
The high stresses in propeller blades and hubs naturally require extremely high quality steels. Accordingly, the U.S. Army and U.S. Navy have set up rigid quality specifications requiring that every heavily stressed part must be magnafluxed several times during its production.

With USS CARILLOY 4340 electric furnace aircraft quality steel, this important manufacturer is able to count on the performance required for this severe application. The consistent high quality of USS CARILLOY aircraft steel has meant greater savings to this customer through minimum magnaflux rejections of costly fabricated parts.

USS CARILLOY steels have established an enviable record for meeting the highest quality requirements. Therefore, when you need a standard AISI analysis or a special steel for an unusual application, it pays to call in a USS Service Metallurgist. He can help you solve any steel problem.



THESE HIGH QUALITY aircraft propeller hubs are forged and machined from semifinished CARILLOY 4340. They meet extremely tough magnaflux requirements.



AFTER FORGING AND MILLING, 750-lb. thrust sections are hogged out on this Kellering machine. Finished sections weigh about 155 lbs. USS CARILLOY steel maintains a No. 1 quality position on these heavy-duty parts.

FOR BIG PROPELLERS, 2 forged sections (**a**) are welded together to form one blade thrust member. Pieces are then ground and magnafluxed, Kellered, ground, and magnafluxed again (**b**). Mill camber sheets (**c**) then are copper brazed to the thrust members. Entire unit is heat treated and polished before final magnaflux test and cadmium plating. Rigorous magnaflux testing assures that every finished blade (**d**) can withstand the tremendous stresses encountered on the latest high-speed planes.

USS

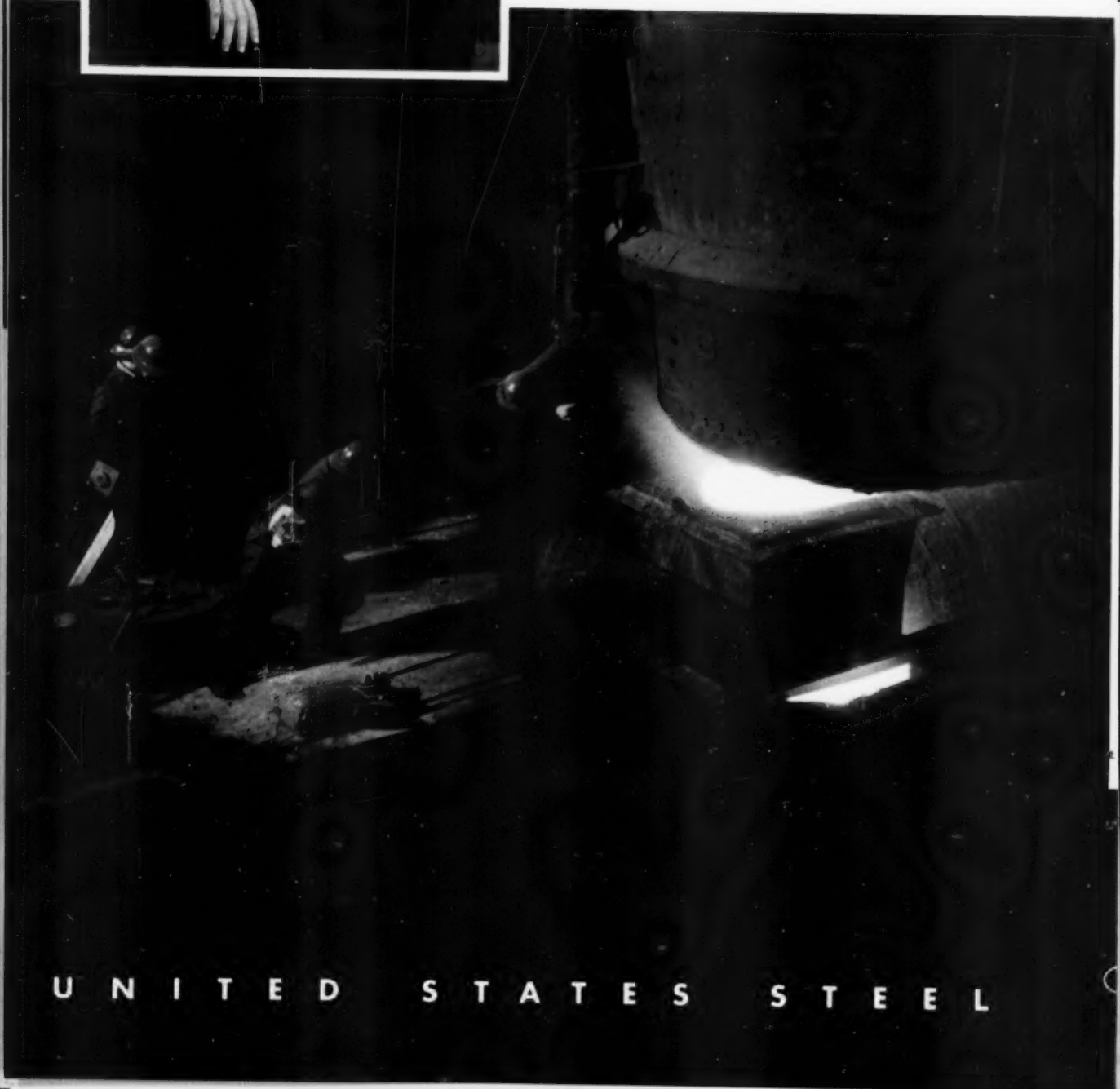
UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO

TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS COAST TO COAST

UNITED STATES STEEL

"We scrap 90 tons of steel

says John E. Williams
U.S. Steel
Open Hearth Pit Boss



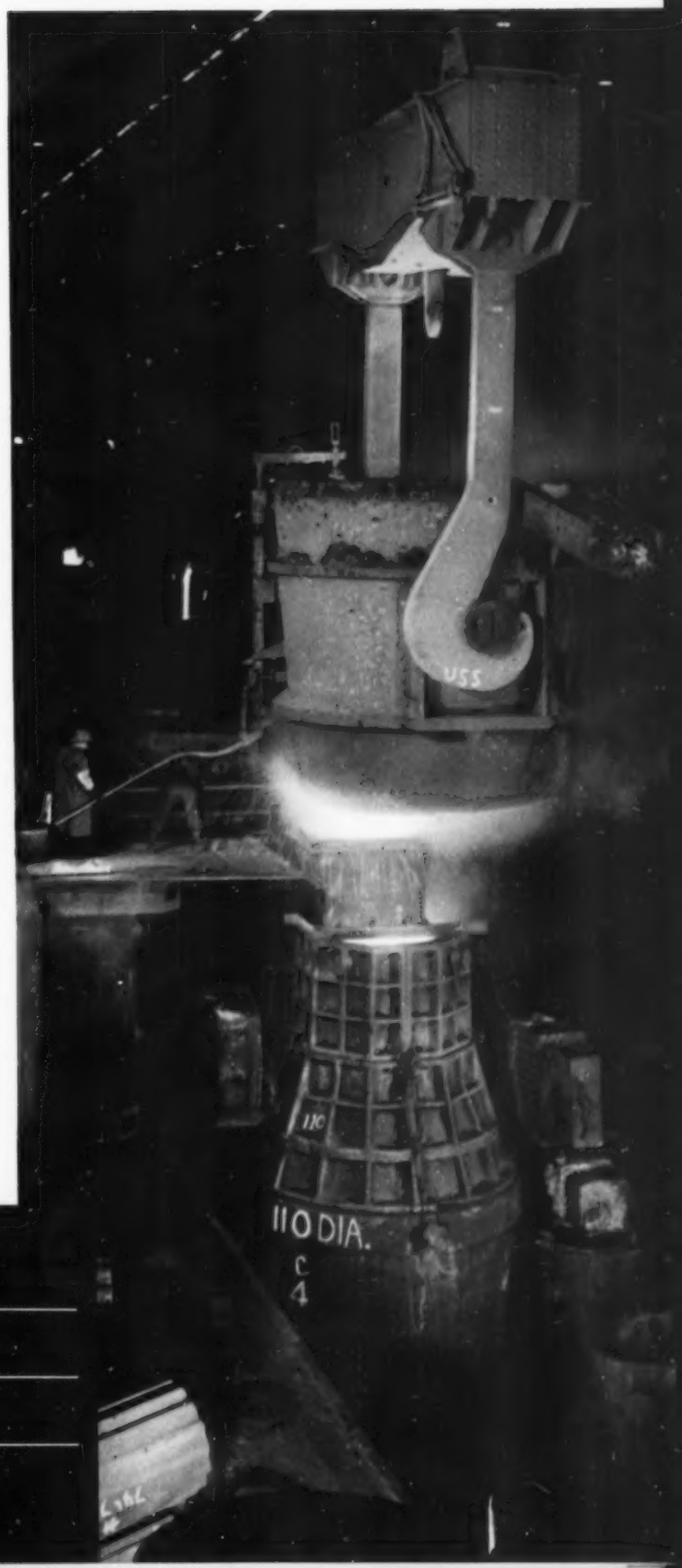
UNITED STATES STEEL

to make a better forging"

• In his role as Pit Boss, John E. Williams is responsible for the pouring side of the open hearth and the thousand and one details involved before the furnace is tapped and the molten metal poured into ingots. He is shown here supervising the pouring of a 110-inch-diameter forging ingot at our Homestead Forgings Division. This gigantic ingot mold is filled with 525,000 pounds of alloy open hearth steel—yet it is poured as *one heat* from a *single furnace*.

Look again at the ingot mold in the picture. As the ingot is forged, we will cut off and discard the top 25%—as well as approximately 10% from the bottom of the ingot—over 180,000 pounds of steel. The top of the ingot may be spongy and full of "pipes." Therefore, we scrap this steel and use only the dense center section. The bottom portion may contain impurities, so it too must be discarded. In a very real sense, the quality of a forging is often determined by how much of the ingot is thrown away, and we throw away plenty.

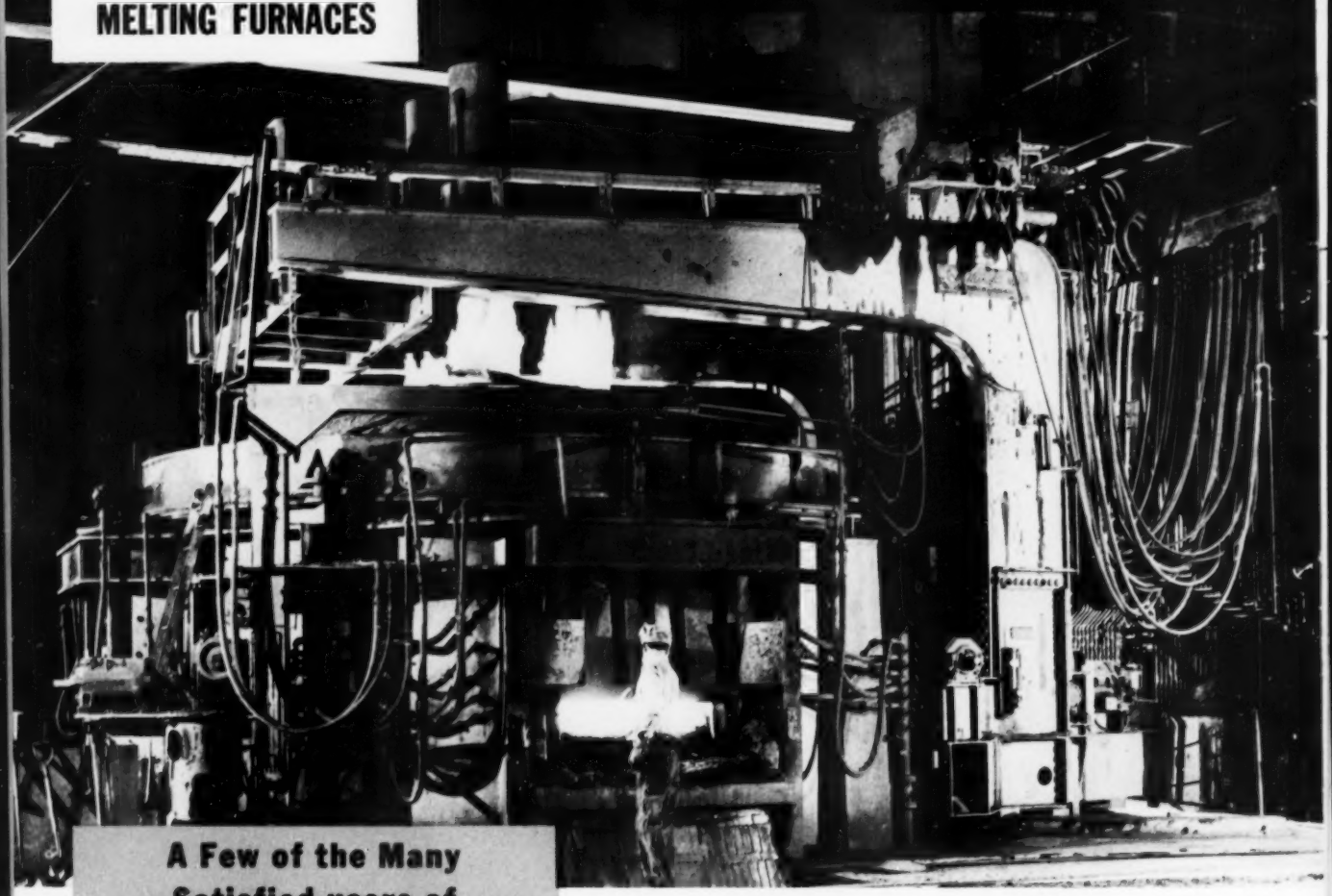
Write today for our free 32-page booklet that describes the steel, the machines and the men that produce every USS Quality Forging. Address inquiries or requests for the booklet to United States Steel, Room 4367, 525 William Penn Place, Pittsburgh 30, Pa. 4-237



USS Quality

Heroult
ELECTRIC MELTING FURNACES

TOPS FOR PRODUCTION OF HIGH GRADE STAINLESS, ALLOY AND RIMMING STEELS



A Few of the Many Satisfied users of HEROULT FURNACES

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Allegheny Ludlum Steel Corporation
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Ingersoll Steel Division, Borg-Warner Corp.
McLouth Steel Corporation
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Republic Steel Corporation
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EMBODYING the latest in mechanical and electrical equipment, these widely used furnaces are noted for their efficient performance, safety, and low operating cost and maintenance.

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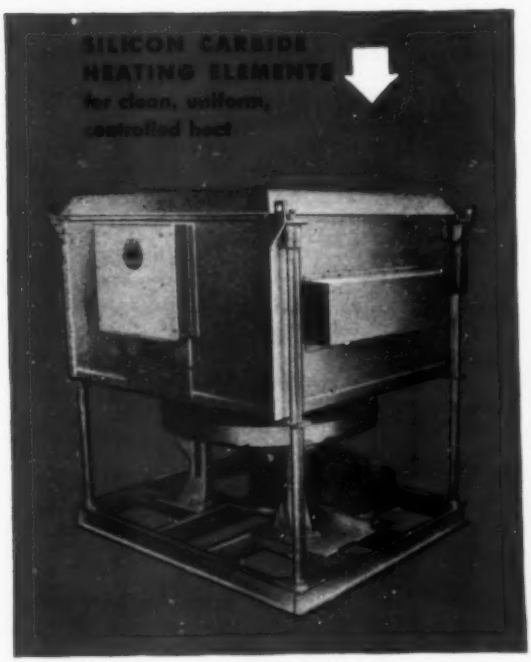
USS

UNITED STATES STEEL

Silicon carbide makes this a better furnace . . . *two ways*



AN INTERESTING FEATURE of this W. S. Rockwell controlled atmosphere furnace is that both the heating elements and rotary hearth are made of silicon carbide.

The elements provide clean, uniform, *controlled* heat. Example: an automotive manufacturer using several of these furnaces, heats steel slugs for forging at 2200 F — and regularly turns out 500 lbs per hr per furnace.

The silicon carbide hearth provides an even work surface *that wears, and wears, and wears.* It stays clean, requires far less maintenance, and the work is easier to handle. Both the heating elements and hearth are products by

CARBORUNDUM

Registered Trade Mark

• **FREE LITERATURE**

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The Carborundum Co., Perth Amboy, N. J.

Here are dozens of examples of how to make your heat-treating furnace perform better.

☐ CARBOFRAX® silicon carbide refractory applications in heat treating furnaces.

☐ GLOBAR® silicon carbide heating elements.

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SPEED... The fastest quench this side of water — if you need it. Or a slower speed oil, if that is required.

SURETY... Uniform quenching results, heat after heat, month after month.

STABILITY... No breakdown, no sludge, no light ends to "crack off," for Houghto-Quench is fortified for stability and long life.

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Ready to give you on-the-job service . . .

"SERV-RITE"
THERMOCOUPLE
HEAD

the head that's ahead in every way . . .

This new "Serv-Rite" thermocouple head is actually small enough to be held comfortably in the palm of your hand. But size is only one of the many features that make this thermocouple head really extraordinary. It is loaded with installation and service conveniences that any user of thermocouples will appreciate at once.

The body is of malleable iron, cadmium plated for durability. A new type friction lock assures easy removal or tightening of the cap — a quarter turn does it. An asbestos gasket makes the head dirt- and moisture-proof. With a choice of ½", ¾", or 1" IPS opening for the protecting tube, you can standardize on one style head.

The connector block is of a material especially selected to withstand, without damage, temperatures up to 900° F. in continuous service. Improvements over the conventional type of inserts greatly simplify the making of the lead wire connections. The complete thermocouple element, including connector block, can be easily withdrawn for inspection.

Install a "Serv-Rite" thermocouple head and see for yourself how much better it really is.

Write for complete details

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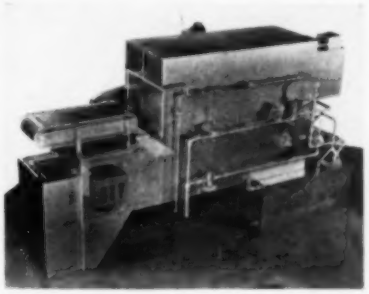
tank, quench tank conveyor, together with loading and furnace conveyors. It operates on 110 volt current, and



requires no special installation; 220 to 440 volt operation is optional. The overall dimensions are 6½ by 6 by 7½ ft.

For further information circle No. 1518 on literature request card on p. 36-B.

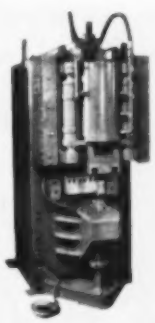
Phosphatizing Process

A new process has been announced by the Diversey Corp., which makes it possible to phosphatize steel and also apply silicone finishes. The new process is claimed to clean, rust-proof and give greater finish adherence to the metal in one spray application. Since silicone paints do not adhere after usual phosphatizing processes, the advantages of rust-proofing have not been possible for products like heaters, electric motors, furnaces, radiators and other products where heat is a factor.

For further information circle No. 1519 on literature request card on p. 36-B.

Projection Welder

A new projection welder which combines high welding pressure with fast ram action has been announced by the Universal Welder Corp. Particularly suited to the welding of light metals and to other applications requiring high pressures and quick follow-up, the machines are rated at from 5000 to 18,000 psi. over a size range of from 250 to 500 kva. The ram is equipped with a double-acting pressure head of the zero-friction diaphragm type. The units have welding strokes over a ½ to 2 in. range and may be had with an adjustable retraction-stroke ram providing 3 to 6 in. additional travel. They are available with standard throat depths of 12 to 48 in. in 6 in. steps.



For further information circle No. 1520 on literature request card on p. 36-B.

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Instruments for precision temperature measurement

The Simplified PYRO Optical Pyrometer

Gives Accurate Temperatures at a Glance!

Any operator can quickly determine temperatures on minute spots, fast-moving objects and smallest streams. Completely self-contained. No calibration charts or accessories needed. An accurate, direct-reading Pyrometer that pays for itself by helping prevent spoilage. Weighs 3 lbs. Available in 5 temperature ranges (1400° F. to 7500° F.).

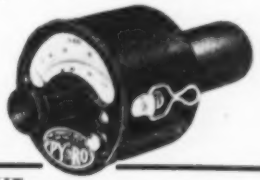
Ask for *free* Catalog No. 85.

The Improved PYRO Surface Pyrometer

The ideal instrument for all plant and laboratory surface and sub-surface temperature measurements. Available with large selection of thermocouples and extension arms for all jobs. Designed for ruggedness and accuracy . . . it features automatic cold end compensation, large 4½" direct reading dial and shock, moisture and dust-proofed shielded steel housing. Stock ranges 0-900° F. to 0-1200° F. Ask for catalog No. 168.

The New PYRO Radiation Pyrometer

Tells spot temperature instantly—in heat-treating furnaces, kilns, forgings and fire boxes. No thermocouples, lead wires or accessories needed! Temperature is indicated on direct-reading dial at a press of the button. Any operator can use it. Write for FREE Catalog No. 100.



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New Plant and Laboratory

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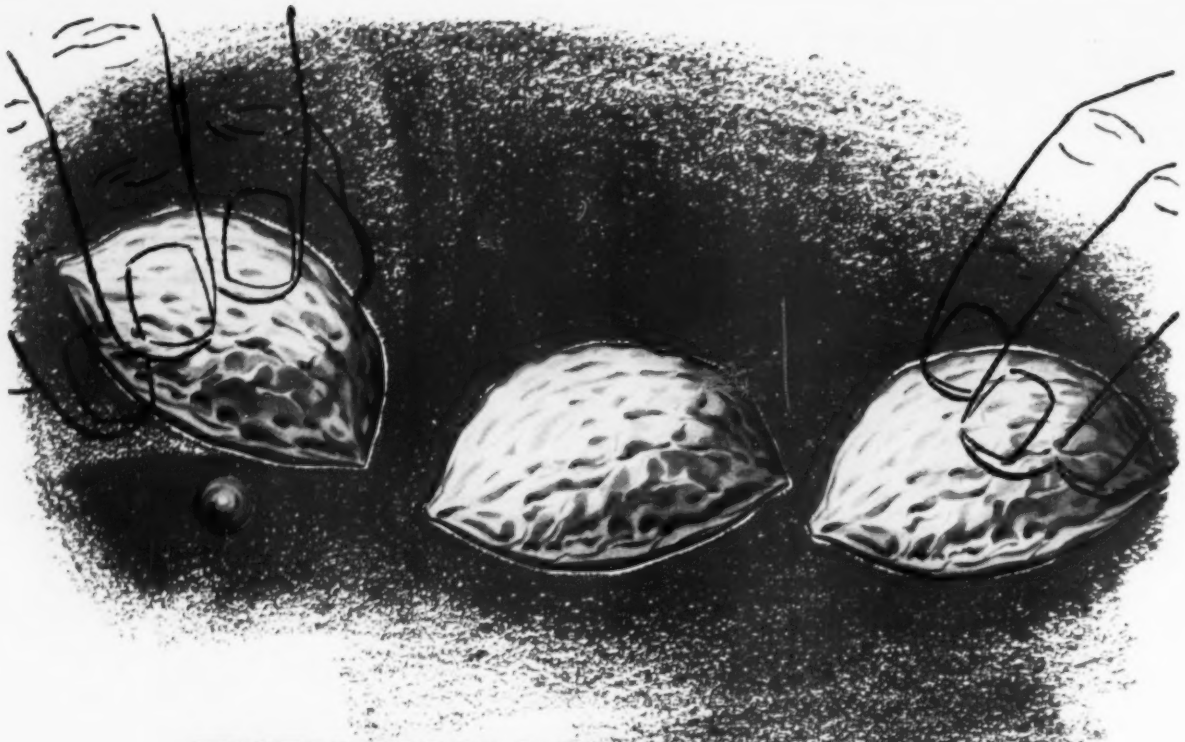

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...but there's a big difference underneath

And it's the same way in buying carbon or alloy steel tubing. Lots of it looks very much like OSTUCO . . . but underneath it all there are these advantages that save you money:

OSTUCO provides a single source service . . . complete manufacturing, fabricating and forging operations under one roof mean one purchase order takes care of all details. And you can depend on deliveries as promised. OSTUCO'S flexibility assures the same efficiency and economy in both large or small production runs. OSTUCO'S quality control maintains uniformity of structure from raw materials to finished product.

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1549. Alloy Steel
16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

1550. Alloy Steel
68-page "Aircraft Steels" includes revised military specifications. Also stock list. *Ryerson*

1551. Aluminum Coating
Article on hot dip coating of ferrous metals with aluminum and aluminum alloys from "Tips and Trends". *Ajax Electric*

1552. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

1553. Ammonia
18-page booklet on ammonia and its uses and ammonia installations for metal treating. *Armour Ammonia*

1554. Analysis of Nickel Alloys
52-page Technical Bulletin T-36, "Methods for Chemical Analysis for Nickel and High-Nickel Alloys". *International Nickel*

1555. Anodizing Magnesium
Article on a new anodic coating for magnesium. *Dow Chemical*

1556. Architectural Aluminum
16-page booklet on aluminum products for architectural use, aluminum structural shapes, embossed finishes on aluminum. *Reynolds Metals*

1557. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

1558. Atmosphere Furnace
Reprint on bright annealing of copper in atmosphere furnace. *Holcroft*

1559. Balances
Bulletin No. 329 on precision balances with projection readings. *Burrell*

1560. Barrel Finishing
32-page handbook on compounds for descaling, deburring, coloring, metal cleaning and rust inhibition. *Lord Chem.*

1561. Bending
Catalog on presses for bending, forming, blanking, drawing and multi-punching. *Cleveland Crane & Engineering*

1562. Bending
24-page article on in-plane bending properties of welding elbows. *Taylor Forge & Pipe Works*

1563. Bending and Cutting
Folder describes hand and air-operated bender-cutter and its applications. *J. A. Richards*

1564. Beryllium
20-page booklet describes beryllium products, including the pure metal, oxide and alloys. *Beryllium Corp.*

1565. Beryllium Copper
Bulletin 1 on available alloys, conditions, tempers and tables of sizes and properties. *Penn Precision Products*

1566. Beryllium Copper Tubing
Memorandum No. 7-2 on properties, applications and advantages of seamless weldrawn beryllium copper tubing. *Superior Tube*

1567. Bimetal Applications
36-page booklet, "Successful Applications of Thermostatic Bimetal", describes 22 uses and gives engineering data. *W. M. Chace*

1568. Black Oxide Finish
Folder on penetrating black finish for ferrous metal. *Puritan Mfg.*

1569. Blast Cleaning
6-page booklet on pressure blasting process and its applications in the field of deburring, cleaning, scale removal. *Cro-Plate Co.*

1570. Blast Cleaning
28-page booklet on accessories and supplies for blast cleaning. *Pangborn Corp.*

1571. Blowers
Bulletin 100-53 on combustion air blowers of 8 to 20 oz. pressures. *Western Products*

1572. Boron Additive
6-page article on use of grainal as boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

1573. Brass
Bulletin B-39 on Formbrite drawing and forming brass. *American Brass*

1574. Brass Tubing
Bulletin on seamless, brazed and lockseam tubing in brass and copper. *H & H Tube and Mfg.*

1575. Brass Wire
10-page booklet gives properties, finishes, chemistry of extruded cold heading brass and copper wire. *Chase*

1576. Braze-Carburize
Article on simultaneous brazing and carburizing of hand tools. *Ajax Electric*

1577. Brazing Applications
48-page manual on all aspects of silver brazing applications and problems. *American Platinum Works*

1578. Brazing Stainless Steel
Illustrated booklet, "Bright Annealing, Hardening and Brazing Stainless Steel", describes conveyor furnace and bright brazing alloy. *Sargeant & Wilbur*

1579. Bright Carburizing
Job data on bright carburizing and hardening gears. *Ipsen*

1580. Bronze Bearings
New brochure on bearing bronze. *American Smelting and Refining Co.*

1581. Bronze Electrodes
Bulletin on characteristics and properties of various grades of bronze electrodes. *Ampco*

1582. Buffing and Polishing
Brochure on facilities for production buffing, polishing and deburring. *Am. Buffing and Polishing*

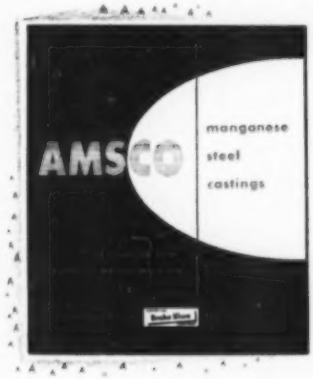
1583. Carbon and Graphite
20-page catalog on carbon and graphite applications in metallurgical, electrical, chemical, process fields. *National Carbon*

1584. Carbon and Sulphur Determination
Bulletin No. 310 on tube furnaces for carbon and sulphur determination. *Burrell*

1585. Carbon Control
Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Eng'g.*

1586. Carbon Steel Castings
Data folders on four types of carbon steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

1547. Manganese Steel Castings
Where impact and abrasion are major causes of wear, manganese steel castings are usually considered. This 24-page book



points out such uses as for dippers, buckets, liners, hammers, jaw plates, wheels, rollers, chain, pumps and others. *American Manganese Steel Div.*

1587. Carburizing
Data folder on Aerocarb E and W water-soluble compounds for liquid carburizing. Case depth vs. time curves. Per cent carbon and nitrogen penetration curves. *American Cyanamid*

1588. Carburizing
Bulletin on non-burning carburizers. *Park Chemical*

1589. Carburizing Salts
Folder on salts for liquid carburizing. *Swift Industrial Chemical*

1590. Cast Bronze
24-page booklet on cast bronze and copper products gives research, process, engineering and production facilities and includes an alloy chart of principal alloys. *National Bearing Div.*

1591. Castings, Bronze
16-page booklet on sand and centrifugal castings. *Amer. Non-Gran Bronze*

1592. Cemented Carbides
64-page catalog 52 gives latest information on carbide tooling. Completely illustrated details on all types of cutting tools. Handy tables for grade selection and cutting speeds. *Kennametal*

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No matter how keen the competition, there can be only one winner. And the difference between the winner and the runner-up, whether it's golf or making high speed steels, is measured in performance.

Crucible REX® high speed steels have proved their championship qualities under the toughest sort of competition — in actual use in thousands of tool shops throughout the world. But check for yourself. Try a piece of REX high speed steel on your next job. Compare its hardenability, response to heat treatment, its fine tool performance. You won't find another high speed steel to outperform REX.

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1593. Centrifugally Cast Pipe
130-page book on centrifugally spun steel tubes. Specifications, physical requirements, chemical analyses. *American Cast Iron Pipe Co.*

1594. Clad Metals
24-page booklet on principles of bonding, characteristics of clad metals, methods of cladding and applications. *Superior Steel*

1595. Cleaner
Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

1596. Cleaning
6-page bulletin includes concentrations for various metal cleaning applications and a handy list of cleaners for general industrial use. *E. F. Houghton*

1597. Cleaning
New booklet gives case histories of mechanical cleaning with power brushes. *Pittsburgh Plate Glass, Brush Div.*

1598. Cleaning Aluminum
12-page bulletin on cleaning process for preparing aluminum and magnesium for welding. *Northwest Chemical*

1599. Cobalt Alloy
12-page booklet, "Haynes Alloy No. 25", tells of the unique properties of this cobalt-base alloy. *Haynes Stellite*

1600. Color-Coded Temperature Records
Bulletin 427 describes instrument that records up to six temperatures on a single circular chart, each record in a different color. *Foxboro*

1601. Combustion Control
20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

1602. Combustion Control
Folder on mechanical drafting and an air-power ejector. *Morgan Construction*

1603. Controlled Atmosphere
Bulletin on Dewpointer for reading of atmosphere in field and laboratory. Readily portable, operating on a.c. or enclosed battery. *Illinois Testing Labs.*

1604. Controlled Atmospheres
24-page bulletin describes production problems with reference to dry atmospheres. *Pittsburgh Lectrodryer*

1605. Copper Alloys
40-page handbook on phosphor bronze, nickel silver, cupro nickel, beryllium copper. *Riverside Metal*

1606. Copper Nickel Alloys
8-page bulletin on composition, properties and applications of series of 12 copper-nickel-base alloys available in cast form. *Waukesha Foundry*

1607. Core Dryer
12-page bulletin on Foundromatic core dryer and how such drying fits existing setups. *Allis-Chalmers*

1608. Corrosion Data
Bulletin gives comparative resistance to various corrosive media of several stainless steels. *Babcock & Wilcox*

1609. Corrosion Resistance
Chart indicates resistance of seven classes of corrosion resistant cements to 297 of the most generally used corrosive chemicals. *Pennsylvania Salt*

1610. Corrosion Resistance
32-page brochure on causes of corrosion and means of combating them. Choice of materials for condenser tubes. *Revere Copper & Brass*

1611. Corrosion Resisting Coating
Bulletin No. 100 lists, classifies and gives further references to corrosion resistant coatings for numerous purposes. *Carboline*

1612. Creep Testing
Data on operation and instrumentation of Arcweld lever arm creep testing machine. *Minneapolis-Honeywell*

1613. Cut-Off Wheels
Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

1614. Cutting and Grinding
44-page booklet on cutting and grinding procedures. Charts and graphs of recommended concentrations for different metals and operations. *Master Chemical Corp.*

1615. Cutting Compound
Bulletin B-5 on compound for tumbling iron and steel parts. *Apothecaries Hall*

1616. Cutting Fluids
Folder lists types of cutting fluids and their specific applications. *Swan-Finch*

1617. Cutting Fluids
16-page booklet on selection and application of four water-mix cutting and grinding fluids. *D. A. Stuart*

1618. Cutting Oil
Folder on sulphurized cutting fluid for a wide range of machining jobs. *Gulf Oil*

1619. Deep Drawing
Reprint on new deep drawing technique involving single-stroke dies and eliminating intermediate operations. *Schnell Tool & Die*

1620. Degreasing
34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

1621. Degreasing
Pamphlet on properties and use of trichlorethylene. *Niagara Alkali*

1622. Die Castings
Booklet on small zinc die castings. For designers and engineers. *Gries Reproducer*

1623. Drawing Compounds
Folder on lubricant for forming and drawing of stainless. *Hangsterfer*

1624. Drawing Lubricants
Folder lists types of drawing lubricants and their specific uses. *Swan-Finch Oil*

1625. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

1626. Electric Furnaces
8-page booklet on belt conveyor electric furnaces for bright hardening. *Westinghouse Electric Corp.*

1627. Electron Microscope
20-page brochure describes in detail ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories. *RCA*

1628. Extrusion Presses
8-page bulletin on aluminum extrusion presses describes the processes and presses at work. *Watson-Stillman*

1629. Fabrication
46-page book shows metal fabrication and production facilities, products and services. *R. C. Mahon*

1630. Fasteners
4-page catalog on cold forged cap screws of high carbon alloy and stainless steels. *Chandler Products Corp.*

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by Don Harold

COST-CUTTING STORY OF THE PANGBORN BLAST CLEANING MACHINE

Pangborn Blast Cleaning Machine—available in six types, stationary or portable—delivers efficient, low cost maintenance in any plant. $188 up.

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Now... Bristol thermocouples with metal-ceramic protecting tubes

Bristol's new metal-ceramic LT-1 protecting tubes are the most important advance in thermocouple technology in years.

Combining the thermal conductivity and shock resistance of metal with the corrosion and oxidation resistance of ceramic materials, the new protecting tubes will last far longer than ordinary tubes, give you closer control and faster response.

Here are the advantages of the metal-ceramic LT-1's

- Resistance to combustion gases at temperatures up to 3100°F
- Resistance to oxidation in air at temperatures up to 2200°F
- Retention of strength at high temperatures – 1800 to 2500°F
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- Resistance to attack by molten metals and furnace slag
- Increased sensitivity – the ⅛ inch wall has a high thermal conductivity

Get the whole story on Bristol's new tubes. Write for Bulletin P1261 today. The Bristol Company, 106 Bristol Road, Waterbury, Conn.

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Points the Way in Human-Engineered Instrumentation

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

TWO SIMPLE REASONS WHY!

● We will guarantee—in writing—that you'll save money on your blast cleaning costs when you use Permabrasive* shot and grit instead of conventional annealed abrasives. Yes sir, a guaranteed savings in writing.

We can afford to make this statement, because Permabrasive shot and grit are better. They are better for two simple reasons: (1) Permabrasive is made from metal of the proper analysis. Its carefully controlled chemical composition insures uniform response to heat treatment and maximum resistance to breakage. (2) Permabrasive is heat treated properly. A continuous processing method insures complete heat treatment of each abrasive particle, resulting in a high degree of uniformity and assuring maximum abrasive durability.

Permabrasive will save you money and we can prove it. Write the nearest Hickman, Williams office for proof and a complimentary copy of "A Primer on the use of shot and grit."

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CLEVELAND, OHIO

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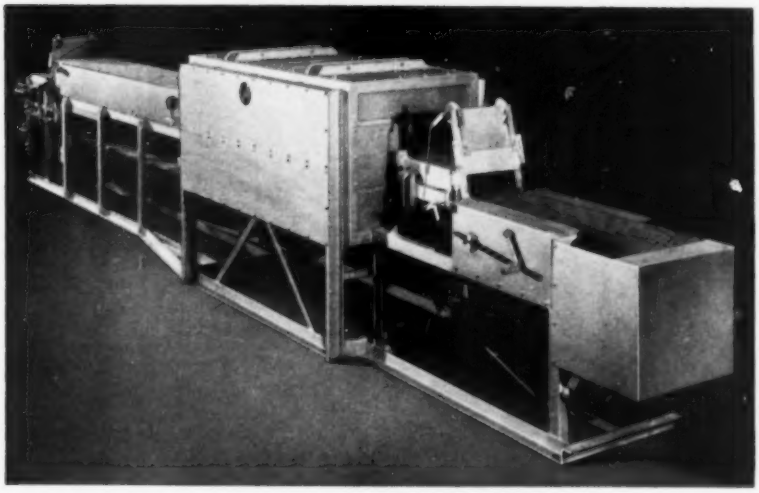

REPLACE Your Outmoded or
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Harper ELECTRIC
Continuous MESH BELT
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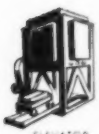
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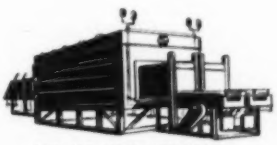
STRAND ANNEALING

● Continuous production heat treatment of your product in a Harper Mesh Belt conveyor furnace will eliminate many costly man hours of handling time . . . what's more, every part receives the same treatment . . . no variations or spoilage because of human error. Closely controlled hot zone accurately and uniformly treats the product.

Harper Mesh Belt Conveyor Furnaces are built to stand hard service. They are highly efficient. High power input makes possible continuous large volume production. Increased production plus sizeable savings in man hours and operating costs accomplished with a mesh belt furnace will soon total above your replacement costs.

Production furnaces available to match your production requirements. Write for information today.

CONTINUOUS MESH BELT CONVEYOR


TWIN AND SINGLE MUFFLE PUSHER

Furnace Builders *for over 30 Years*

HARPER
Electric Furnace Corp.
40 RIVER ST., BUFFALO 2, N. Y.

1631. Ferro-Alloys and Metals
New 104-page book gives data on more than 50 different alloys and metals produced by the company. *Electro Metallurgical*

1632. Filters
8-page bulletin on dimensions and capacities of industrial filters. *Industrial Filtration Co.*

1633. Filters
New 4-page special report of a central filtration installation at Warner & Swasey's New Philadelphia, Ohio, plant. *Industrial Filtration*

1634. Finishing
Bulletin on a coating of pulverized aluminum in a plastic base which may be applied without heat. *Emjay Maintenance Engineers*

1635. Finishing
28-page catalog B-9 on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

1636. Flame Analysis
New, pocket-size card with emission spectra for 36 of the most typical elements. *Beckman Instruments*

1637. Flame Rectifiers
Bulletin 9604 on new miniature flame rod assemblies, photocell units, pilots and other components used in combustion snfeguard systems for industrial oil and gas burners. *Minneapolis-Honeywell*

1638. Flow Meters
24-page manual on application and installation of indicating flow meter. *Meriam Instrument*

1639. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g*

1640. Flow Regulation
Folder on self-operated flow regulator. *Fischer & Porter*

1641. Fluoroscopy
12-page booklet on fluoroscopy for nondestructive internal inspection. Explains image amplifier. *Westinghouse Electric, Industrial X-Ray Dept.*

1642. Forgings
Handsome 32-page brochure on large forgings for turbine shafts, rotors, drop hammer anvils, rolls. *U. S. Steel*

1643. Forming Dies
Folder on styles of forming dies for stainless heads—in wide range of sizes and gages. *Carlson*

1644. Foundry Practice
4-page folder on Transite core plates and slip jackets and a new asbestos product for plates and form driers. *Johns-Manville*

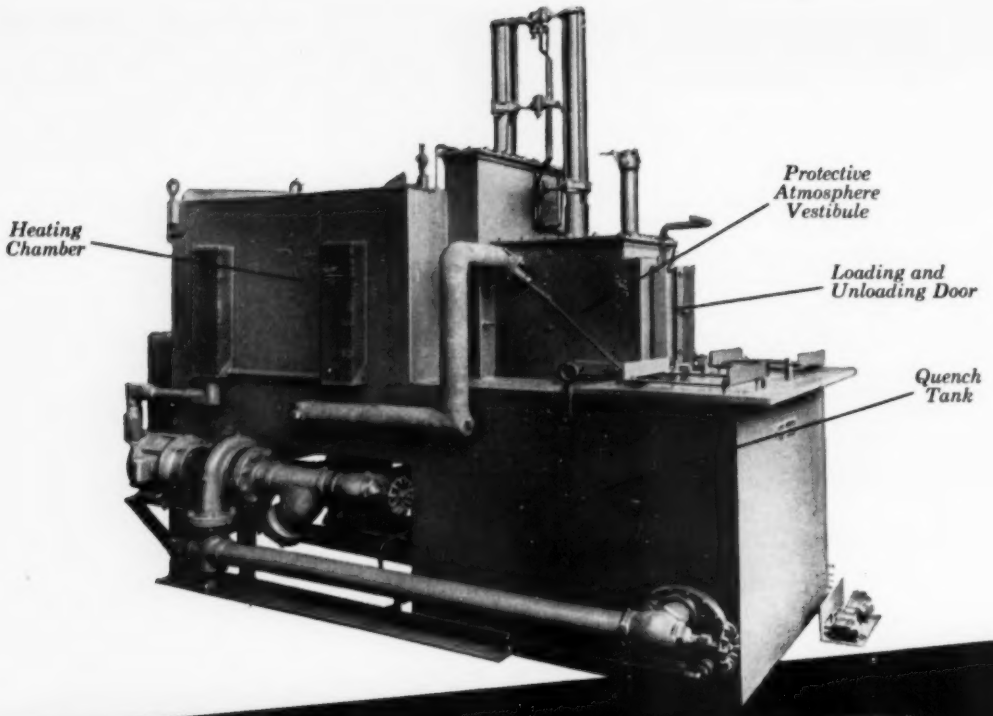
1645. Foundry Practice
20-page Lavingot Journal No. 10 gives chart on specifications and test bar designs of nonferrous ingot and casting alloys. *Lavin*

1646. Freezer
8-page folder on portable freezer, 110-volt a.c., operating to —180° F., for shrink fitting, hardening, stabilizing and testing. *Webber Mfg.*

1647. Furnace Controls
Bulletin on instruments and controls for heat treating furnaces. *Hays Corp.*

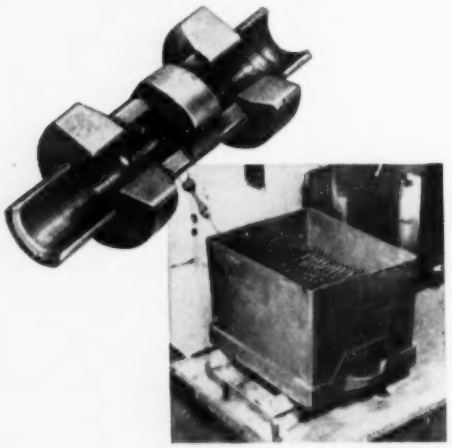
1648. Furnace Fixtures
Bulletin T-227 on Thermalloy trays and fixtures. *Electro-Alloys Div.*

1649. Furnaces
High temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*



ATMOSPHERE-CONTROLLED HOMOCARB® cuts cam finishing costs $45 per load

Finished cam of 1117 steel shown full size.



Tray of loaded cams. Layers are separated by wire mesh screens.

• Cam assemblies such as the one shown here are made in lots of 750 for a small precise mechanism. In an effort to improve their already good quality, the manufacturer recently began to heat treat them in a horizontal Homocarb furnace with Microcarb® atmosphere control.

With this equipment, active carbon in the atmosphere surrounding the work is under continuous, automatic control during both the heating and quenching operations.

Parts are loaded in 12″ x 18″ x 10″ trays . . . 125 cams per layer, 6 layers per load . . . then held at 1600F for 2 hours with a carbon set point of .95%. Parts are oil-quenched, without being exposed to air.

As to quality, sample cams taken from top, center and bottom of a load show surface carbon always between .93 and .96C, with corresponding uniformity of case depth.

In addition . . . and here's the unexpected, direct saving . . . cams are so clean that 6 cents per cam, or $45.00 per load, is saved in subsequent finishing. The combination of heating and quenching in a precisely-controlled atmosphere is earning this dividend.

For complete information about Homocarb furnaces with Microcarb atmosphere control just write us at 4927 Stenton Ave., Philadelphia 44, Penna.

LEEDS *instruments* **NORTHRUP** *automatic controls • furnaces*

1650. Furnaces
Bulletin describes 18 electric furnaces for research and small-scale production, with operating temperatures to 3000° F. *Harper Electric Furnace*

1651. Furnaces
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

1652. Furnaces
12-page brochure on car furnaces of special and conventional design. *Jet Combustion*

1653. Furnaces
Bulletin 437 on various types of belt conveyor furnaces. *Rockwell*

1654. Furnaces
New brochure on metallurgical furnaces in the melting, reheating and heat treating fields. *Rust Furnace Co.*

1655. Furnaces
Bulletin 162 on high speed furnaces for forging, upsetting, extruding, stress relieving. *Surface Combustion*

1656. Furnaces, Heat Treating
Catalog on furnaces for tool room and general purpose heat treat. *Cooley*

1657. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

1658. Furnaces, Heat Treating
Bulletin on furnaces for annealing, normalizing, hardening, tempering, forging. *Flinn & Dreffein Eng'g.*

1659. Furnaces, Laboratory
Data sheets on complete line of laboratory furnaces for metallurgical operations. *Boder Scientific*

1660. Gas Analysis
Folder on gas analysis equipment for thermal conductivity measurements. *Leeds & Northrup*

1661. Globar Furnaces
Bulletin 153 describes nine types of furnaces using silicon carbide heating elements for temperatures to 2600° F. *Hevi Duty*

1662. Gold Plating
Article on analysis of gold and gold alloy plating solutions gives all currently available procedures. *Technic*

1663. Graphite Electrodes
Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. *Great Lakes Carbon Corp.*

1664. Graphitic Tool Steels
48-page booklet on heat treating data, properties and 46 specific applications of graphitic tool steel. *Timken*

1665. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

1666. Hard Surfacing
12-page article on selection and evaluation of methods of hardfacing. *Air Reduction Sales*

1667. Hardening Stainless
24-page "Story of Malcomizing" describes surface hardening of stainless steels. *Lindberg Steel Treating Co.*

Rapid
RESISTANCE TESTING

with the Rubicon
LIMIT BRIDGE

Built for speedy, accurate production testing of resistors, coil windings, heater elements, percussion caps and other similar items where inspection costs must be minimized.

- Wide Range — 1 ohm to 10 megohms.
- Simple — for use by unskilled operators.
- Fast — speeds of 2000 items per hour possible.
- Sturdy — for year in and year out service.
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- Versatile — suitable for rapid sorting into numerous tolerance bands.
- External Standards — permit automatic temperature compensation when required.

Fully described in Bulletin 100

RUBICON COMPANY
Electrical Instrument Makers
3758 Ridge Avenue Philadelphia 32, Pa.

Eliminate Corrosion from Electrical Contacts with
RHODIUM PLATING

Rhodium plating is finding increased use by electronic design engineers where hard, corrosion resistant electrical contact surfaces are required. Rhodium provides a stable contact resistance and allows use of higher pressures in sliding contacts.

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Write for Booklet 16.

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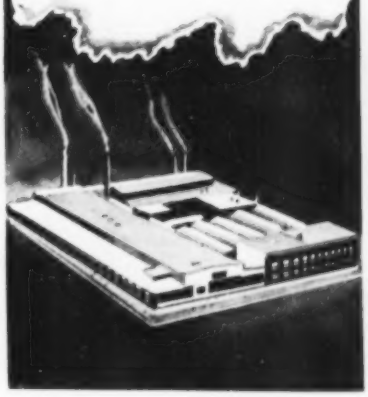


From the batch type installation at the left martempering base detonator fuses, to the huge mechanized furnaces austempering automobile bumpers illustrated below, Ajax Electric Salt Bath Furnaces are replacing old-style quench and temper methods for a wide variety of steel products.

From ring gears to plow points . . .

From bearing races to cast iron cylinder sleeves . . .

From uniformly shaped metal parts to odd and irregular sizes . . .

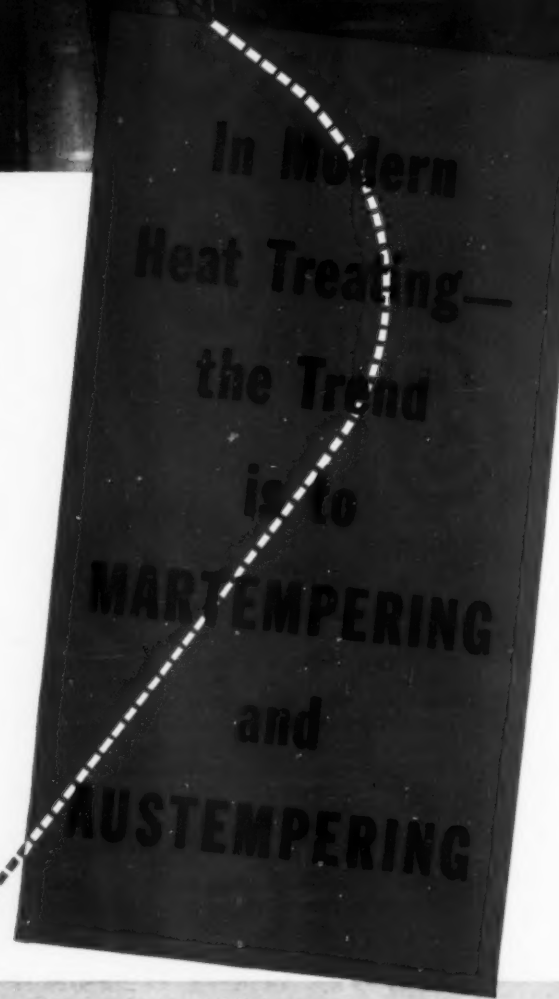
Scores of installations have proved the tremendous possibilities for economy, greater speed and efficiency in martempering and austempering, because all water and oil quenches are eliminated.

Distortion is so negligible that parts can be machine finished *before* hardening. Final grinding is eliminated or materially reduced. Scale, decarb and quench cracks are eliminated. Toughness and ductility are increased. The work is done materially faster—in less floor space—with lower labor costs. Let the Ajax Metallurgical Service Laboratory prove these claims on a specimen batch of your actual parts, under actual working conditions.

Write for Ajax Bulletin 120

AJAX ELECTRIC COMPANY

910 Frankford Ave., Philadelphia 23, Penna.



World's largest manufacturer of electric heat treating furnaces exclusively

AJAX ELECTRIC SALT BATH FURNACES

1668. Hardness Numbers
Pocket-size table of Brinell hardness numbers incorporating other tabular information. *Steel City Testing*

1669. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

1670. Hardness Tester
Literature on Brinell testing machines. *Detroit Testing Machine Co.*

1671. Hardness Tester
Bulletin ET 469 on new portable hardness tester. *Newage International*

1672. Hardness Tester
13-page booklet on microhardness tester with optional Vickers or Knoop diamond. *Geo. Scherr*

1673. Heat Exchangers
Bulletin No. 120 on exchangers used in cooling or controlling temperatures of industrial liquids. *Niagara Blower*

1674. Heat Resistant Alloy
10-page article on how to get its best service out of standard grades of heat resisting alloys by proper selection. *Rolled Alloys*

1675. Heat Resistant Alloy
Bulletin No. 1 on HR-3 (37% Ni, 17% Cr) cast alloy for parts subject to corrosion and high temperatures. *Standard Alloy*

1676. Heat Resistant Finish
Bulletin 531 on silicone-base heat-resistant finish. *Midland Ind. Finishes*

1677. Heat Treat Baskets
Bulletin on wire mesh baskets for heat treating and plating. *Wiretex Mfg.*

1678. Heat Treating
56-page "Heat Treating Alloy Steels". *Republic Steel*

1679. Heat Treating
4-page article on automatic heat treating line with either oil or water quench. *Am. Gas Furnace*

1680. Heat Treating
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

1681. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

1682. Heat Treatment
Bulletin 200 on car hearth, rotary hearth, pit, roller hearth, belt, chain, pusher and "hi-head" furnaces. *R-S Furnace*

1683. Heating
New booklet compares induction and dielectric high frequency heating. *New Rochelle Tool Corp.*

1684. Heavy Duty Cleaning
Booklet on LP cleaner for all metals except aluminum. *Cowles*

1685. High-Alloy Castings
Bulletin 3150-G on castings for heat, corrosion, and abrasion resistance. *Duraloy*

1686. High Speed Steel
New bulletin on structure and properties of "desegatized" high speed tool steel. *Latrobe*

1687. High Speed Steels
Catalog of grades, applications, heat treatment of high steels. *Vanadium-Alloys Steel*

1688. High-Temperature Alloys
Booklet "Keep Operating Costs Down When Temperatures Go Up." *International Nickel*

1689. High-Temperature Tubing
Folder 151 on 8 to 10% Cr, 1% Mo steels for tubing used in elevated temperature service. *Babcock & Wilcox*

1690. High-Tensile Steel
Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

1691. Immersion Pyrometer
Catalog No. 155 on new immersion pyrometer. *Pyrometer Instrument Co.*

1692. Induction Heating
Bulletin on low-frequency (60-cycle) induction heating furnace for non-ferrous metals. *Magnethermic*

1693. Induction Heating
60-page catalog tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1694. Induction Heating
A new 8-page bulletin on forging with induction heat includes case histories, benefits to the forging industry. *General Electric*

1695. Induction Melting
8-page article describes use of induction melting in improved technique for rotor-casting. *Ajax Engineering*

1696. Industrial Furnaces
Booklet 127 on furnaces, ovens, dryers, and special automatic machines for industry. *Continental Industrial Engineers*

1697. Inspection
Data on conveyorized auxiliary unit which may be used with standard Magnaflux for rapid production inspection. *Magnaflux*

1698. Instruments
New 24-page catalog 5001 on industrial instruments and equipment. *Minneapolis Honeywell*

1699. Insulation
New edition of 40-page industrial products catalog on insulations, refractory products, and others. *Johns-Manville*

1700. Laboratory Equipment
16-page book on Lindberg laboratory furnaces, controls, hot plates, carbon determinators. *Boder Scientific*

1701. Laboratory Furnaces
26-page "Construction of Laboratory Furnaces" contains many diagrams, charts, tables, and information on how to construct furnaces. *Norton*

1702. Low-Alloy Steel
60-page book on high-strength low alloy steel, properties, fabrication and uses. *U. S. Steel*

1703. Low-Temperature Properties
Article on application of extreme low temperatures to metallurgy. Behavior of metals at low temperatures. *Arthur D. Little*

1704. Lubricant
Uses of colloidal graphite for piercing, forging, stretch forming and wire drawing operations. *Acheson Colloids*

1705. Lubricant
8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

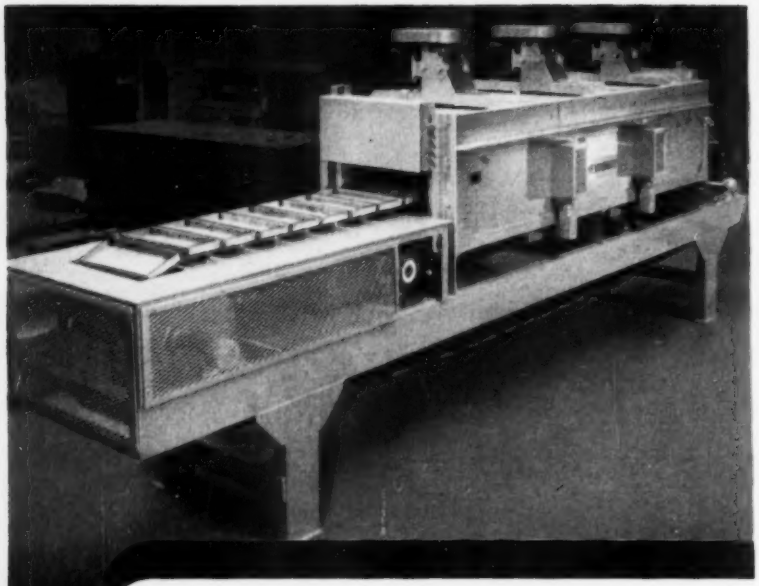
GET THE FACTS

About Hardness Testing

Everything you need to know about hardness testing is told in this handsome book, prepared by the makers of the internationally respected CLARK Hardness Testers for "Rockwell Testing." Simple, easy-to-read text (in English) and numerous illustrations show the equipment and procedure for fast, accurate hardness testing of ferrous and non-ferrous materials. If you would like a copy, *free of charge*, just attach this ad to your letterhead or write "Send book." A copy will be mailed to you promptly.

P.S. If you are interested in descriptions and prices for CLARK Hardness Testers (Standard and Superficial) of *guaranteed accuracy*, say the word and we'll gladly supply them.

CLARK **CLARK INSTRUMENT INC.**
10202 Ford Road • Dearborn, Mich., U.S.A.



Specially Designed
for Continuous Production

HEVI DUTY

CONVEYOR FURNACE

Of special design for Kohler Co. of Kohler, Wisconsin, this Hevi Duty Conveyor Furnace is being used to heat aluminum and brass billets prior to forging jet engine and other parts. Not only has this furnace been designed for a specific job, but Hevi Duty Engineers also built into this furnace many additional features.

- Notice the three fans which speed the heating of the billets by circulating the heated air, and also assure a uniform temperature in the heating chamber. With this feature, a smaller, more economical furnace is able to do this production job.
- Heat resistant alloy conveyor links and trays mean years of dependable service.
- Versatility . . . by using a variable speed drive to adjust the conveyor speed, this furnace can be used for annealing, tempering, and other heating operations.

Special Hevi Duty Furnaces can be engineered to your specifications and your production system. Let us know your requirements. Our engineers will work with you.

HEVI DUTY ELECTRIC COMPANY
MILWAUKEE 1, WISCONSIN
Heat Treating Furnaces... Electric Exclusively
Dry Type Transformers Constant Current Regulators

1706. Lubricant
New literature on anti-seize molybdenum disulfide lubricant. *Bel-Ray*

1707. Lubricants
10-page booklet lists and describes hydraulic oils, gear oils, greases and other lubricants. *Swan-Finch*

1708. Machining Costs
12-page "Relation of Machining Time to Material Cost". Comparative machinability costs per ton for eleven steels. *La Salle Steel*

1709. Magnesium
Dimensions, analyses, property data of magnesium plate and sheet. *Brooks & Perkins*

1710. Magnetics
8-page booklet on Indox permanent magnets and how permanent magnets work. *Indiana Steel Products*

1711. Melting Aluminum
Bulletin 310 on furnaces for melting aluminum. *Lindberg Eng'g.*

1712. Metal Cutting
64-page catalog No. 29 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. *Martindale Electric*

1713. Metal Sorting
Data on nondestructive sorting tool for raw, semi-finished or finished parts. *Dice*

1714. Metal Working Machinery
48-page booklet on bolt and nut machining, power presses, wire mills and special machining. *Waterbury Farrel Foundry & Machine*

1715. Metallographic Equipment
12-page catalog E-29 describes bright-field equipment for visual observation and photography. *Bausch & Lomb*

1716. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Kent Cliff Laboratories*

1717. Nickel Chromium Steels
8-page bulletin with 28 charts on composition, heat treatment, transformation characteristics and mechanical properties of the standard nickel-chromium steels. *International Nickel*

1718. Nickel Silver
Bulletin on nickel-silver castings. *International Nickel Co.*

1719. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

1720. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

1721. One-Minute X-Ray
Reprints on Land-Polaroid method of X-ray film processing. *Picker X-Ray*

1722. Perforated Steel
4-page bulletin illustrates perforated patterns of carbon and stainless steel for safety, ornamental and screening purposes. *Ryerson*

1723. Phosphate Coating
12-page "Phosphate Coating Chemicals and Processes" gives data on paint bonding, rust proofing, protecting friction surfaces, improving drawing and extrusion. *American Chemical Paint*

1724. Phosphate Coating
Booklet on how to apply better zinc phosphate coatings to steel in preparation for painting. *Oakite*

1725. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

1726. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g.*

1727. Plating
8-page booklet on plating rack designed to make spline section or body of rack a permanent tool. *National Rack*

1728. Plating
Bulletin CR-110-5 describes equipment, bath, operating conditions and control of high-speed chromium plating process. *United Chromium*

1729. Plating Barrels
Bulletin PB 109 on mercil-type tanks and cylinders. *Hanson-Van Winkle-Munning*

1730. Polishing
8-page brochure on burnishing or pivot polishing machines which combine work-hardening, minute shaving and polishing in one single operation. *Carl Hirschmann*

1731. Potentiometer
Bulletin A303 on portable potentiometer indicator. *Foxboro*

1732. Precision Casting
Bulletin on mechanically-operated induction furnace for precision casting. *Ajax Electrothermic*

1733. Precision Casting
12-page book on alloy selection and design for precision casting. *Arwood Precision Casting Corp.*

1734. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

1735. Presses
8-page booklet on specifications and capacities of multiple plunger pillar presses. Design details. *Waterbury Farrel Foundry.*

1736. Presses
16-page booklet on recommendations for modernization and conversion of straight-side and gap-frame double crank presses. *E. W. Bliss*

1737. Process Equipment
New folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

1738. Protective Coatings
50-page booklet describes protective coatings. *Atlas Mineral Products*

1739. Pyrometers
New bulletin, "Temperature Indications," on basic facts about pyrometry and line of pyrometers. *Illinois Testing Laboratories*

1740. Pyrometers
24-page thermocouple and accessory bulletin. *West Instrument*

1741. Quenching
Bulletin 820 on automatic quenching tanks for use with continuous heat treating equipment. *Am. Gas Furnace*

1742. Quenching
Article in "Heat Treat Review" compares hot oil and molten salt quenching. *Surface Combustion Corp.*

1743. Quenching Oil
Bulletin on triple action quenching oil for use after any heat treating medium. *Park Chemical*

1744. Quenching Oil
10-page book on new oils for the quenching process gives results on hot wire quench test and in plant operation. *Sinclair Refining Co.*

(Continued on page 36A)

where Quality counts
in a HEAT RESISTANT FINISH

High Temperature Electric Furnace made by Hevi Duty, Milwaukee, for heat treating high speed steel. Has inside temperatures of 2600°F. Finished in SICON green L6x642.

"DRESS UP" Your Laboratory in COLOR!
. . . with Sicon Silicone Coating

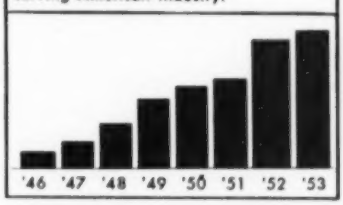
Note how an ordinary heat resistant finish starts to peel and crack a short while after application to heat-producing equipment.

HEVI DUTY uses SICON for protection against heat *and* to give greater color appeal

SICON not only provides better protection for products of the Hevi Duty Electric Company, but adds color appeal, a combination never available before in a heat resistant finish until the advent of silicone resins.

SICON, the original silicone-base heat resistant finish, is now available in various colors. No longer is it necessary to use drab paints and coatings where heat is involved. With SICON, a whole new area of longer product life and decorative finishing is available to the design engineer. For "longer life" and greater "sales appeal" decide now to "SICON-IZE" your products.

Chart below shows 8 year growth of SICON, and reflects how widely it is serving American Industry.



MIDLAND Industrial Finishes Co.
Waukegan, Illinois
ENAMELS · SYNTHETICS
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DEPT. MP6

Write Today for Case Examples of Other SICON Applications on Industrial and Consumer Products.

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Firm_____
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City and State_____

Which Through-Hardening Grade of Alloy Tubing Is Best for You?

...B&W Can Supply Them All

For applications of mechanical tubing that require high strength, ductility, and resistance to impact, the medium-carbon, through-hardening steels are particularly suitable. A correlation of the properties of each available grade with your product specifications will help you determine the grade most suitable for your operation. Listed are the medium-carbon alloy steels typical of those that can be heat-treated to meet a broad range of mechanical properties. These steels all contain alloying elements introduced to provide a desirable combination of strength and ductility and to promote ease of heat treatment. In some grades the alloying elements also provide resistance to softening at higher tempering temperatures.

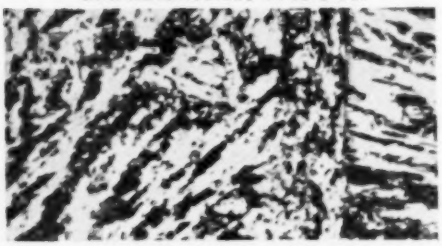
Tubing of these grades may be hot forged without difficulty by conventional methods, and in the softened state is readily machinable—a good indication of the workability common to all the medium carbon through hardening.

In the application of alloy tubing of these steels, it is often possible to use alternate grades without loss of desirable mechanical properties. You'll find Mr. Tubes—your link to B&W—always on call and invariably helpful in any discussion of your tubing requirements. You'll find B&W Bulletin TDC-141 helpful, too. Send for your copy today.

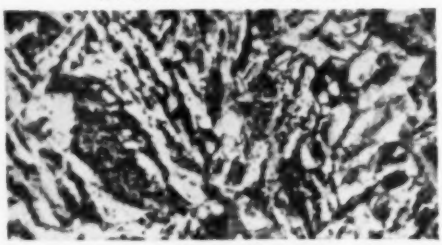
TYPICAL THROUGH-HARDENING GRADES

1340	2340	3140
4042	4140	4340
4640	5140	8640
8740	9440	

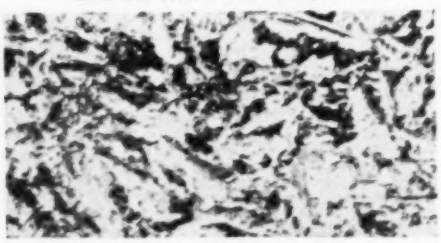
Typical Microstructures (at 1000 X) and Hardnesses, 4140 Steel



Hot Rolled — Hardness 285 BHN



Normalized 1650 F — Hardness 302 BHN



Normalized 1650 F and drawn at 1250 F for 1 hour — Hardness 217 BHN

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

B&W SEAMLESS and WELDED TUBES

TA-4027 (ASM)

(Continued from page 35.)

1745. Quenching Oil
8-page booklet on applications an reductions in oil-quenching install *Sun Oil*

1746. Radiation Protectio
12-page booklet on films for dete ing amount of radiation. Used in re laboratories, nondestructive testin oratories. *Du Pont*

1747. Recording Controll
20-page brochure on new recorde centerless pointer, magnetic stand potentiometric system, and bridge ancing unit in the a.c. bridge s *General Electric*

1748. Refractories
20-page booklet gives technical mation on super refractories. *tories Div., Carborundum Co.*

1749. Resistance Testing
Bulletin 100 on production test measuring electrical resistance. *R*

1750. Rhodium Plating
Rhodium plating as replaceme usual plating metals. *Baker & Co*

1751. Roll Formed Shap
24-page Bulletin 1053 on des forming and producing shapes fro rous and nonferrous metals. *Roll F Products Co.*

1752. Rubber Linings
8-page bulletin on use of rubbe pipes and tanks includes tables o chemical, abrasive and temperatu sistant qualities. *Metalweld, Inc.*

1753. Rust Preventives
12-page bulletin on water-solubl preventive. *Production Specialtie*

1754. Salt Baths
Bulletin H-1 on neutral salt bat their operation. *Park Chemical*

1755. Salt Bath Descalin
12-page bulletin B-40 describe tinuous and batch descaling lin removing oxide from steel, bronz per, stainless and titanium. *Drev*

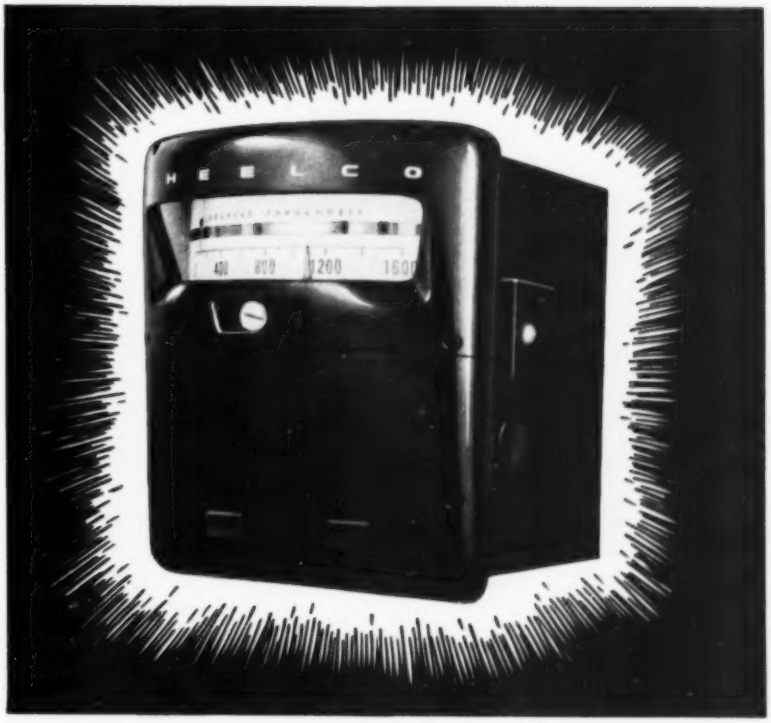
1756. Salt Bath Furnace
Data on salt bath furnaces for and conveyorized work. *Upton*

1757. Saws
Catalog C-53 describes 35 mod metal-cutting saws. *Armstrong-B*

1758. Sand Control
32-page book on defects and t

BARBER COLMAN

NEW Wheelco 400 series Capacitrol



COMING . . . the most modern instrument . . . with four modes of control!

Available this summer, Wheelco's sparkling new Model 400 Series Capacitrols will give you *even more flexible* control . . . *easier servicing* . . . and *lower cost* . . . because plug-in unit construction has been developed to a new high! Any of *four* modes of control are easily, quickly arranged by just inserting the proper control chassis. New, rugged measuring system is of *plug-in* construction, too, and large 6" calibrated scale is easy to read—mirrored to prevent parallox errors. Many outstanding features available for the first time. Anticipate your requirements for the new Series 400 Capacitrol *now —available this summer . . . write for Bulletin F-6314.*

WHEELCO INSTRUMENTS DIVISION

BARBER-COLMAN COMPANY, DEPT. F, 1518 ROCK ST., ROCKFORD, ILLINOIS
Industrial Instruments • Automatic Controls • Air Distribution Products • Aircraft Controls • Small Motors
Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

Which Through-Hardening Grade of Alloy Tubing Is Best for You?

...B&W Can Supply Them All

For applications of mechanical tubing that require high strength, ductility, and resistance to impact, the medium-carbon, through-hardening steels are particularly suitable. A correlation of the properties of each available grade with your product specifications will help you determine the grade most suitable for your operation. Listed are the medium-carbon alloy steels typical of those that can be heat-treated to meet a broad range of mechanical properties. These steels all contain alloying elements introduced to provide a desirable combination of strength and ductility and to promote ease of heat treatment. In some grades the alloying elements also provide resistance to softening at higher tempering temperatures.

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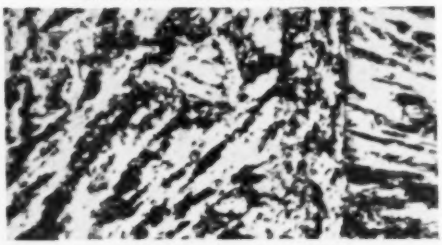
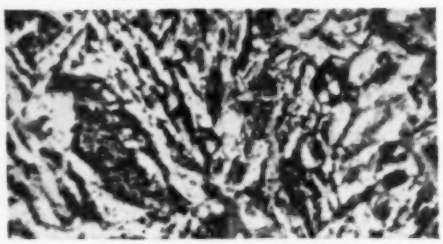
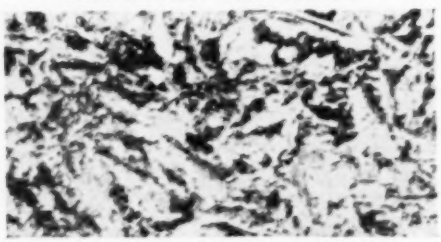
Typical Microstructures (at 1000 X) and Hardnesses, 4140 Steel



Hot Rolled — Hardness 285 BHN



Normalized 1650 F — Hardness 302 BHN



Normalized 1650 F and drawn at 1250 F for 1 hour — Hardness 217 BHN

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio—Welded Carbon Steel Tubing

B&W SEAMLESS and WELDED TUBES

TA-4027 (ASM)

(Continued from page 35.)

1745. Quenching Oil
8-page booklet on applications and cost reductions in oil-quenching installations. *Sun Oil*

1746. Radiation Protection
12-page booklet on films for determining amount of radiation. Used in research laboratories, nondestructive testing laboratories. *Du Pont*

1747. Recording Controller
20-page brochure on new recorder with centerless pointer, magnetic standard in potentiometric system, and bridge balancing unit in the a.c. bridge system. *General Electric*

1748. Refractories
20-page booklet gives technical information on super refractories. *Refractories Div., Carborundum Co.*

1749. Resistance Testing
Bulletin 100 on production tester for measuring electrical resistance. *Rubicon*

1750. Rhodium Plating
Rhodium plating as replacement for usual plating metals. *Baker & Co.*

1751. Roll Formed Shapes
24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. *Roll Formed Products Co.*

1752. Rubber Linings
8-page bulletin on use of rubber lined pipes and tanks includes tables on their chemical, abrasive and temperature resistant qualities. *Metalweld, Inc.*

1753. Rust Preventives
12-page bulletin on water-soluble rust-preventive. *Production Specialties*

1754. Salt Baths
Bulletin H-1 on neutral salt baths and their operation. *Park Chemical*

1755. Salt Bath Descaling
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1756. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

1757. Saws
Catalog C-53 describes 35 models of metal-cutting saws. *Armstrong-Blum*

1758. Sand Control
32-page book on defects and troubles in foundry and how to remedy through sand control. *Claud S. Gordon Co.*

1759. Seamless Tubing
Data on high-temperature, corrosion resistant tubing, which is now commercially available. *Babcock & Wilcox*

1760. Sheet Polishing
Discussion of new techniques for sheet metal polishing. *Acme Mfg. Co.*

1761. Shell Molding
8-page bulletin on silicones for shell molding process. *Linde Air Products*

1762. Shotblasting
16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. *Hickman, Williams.*

1763. Shot Peening
16-page booklet on selection and use of shot and grit for peening. *Cleveland Metal Abrasive*

1764. Silver Brazing
Series of eight technical bulletins on silver brazing. Joint strength, design, stress analysis, heat treatment, fluxes. *Handy & Harman*

1765. Sodium
24-page book on handling sodium in the laboratory and plant. Application to descaling. *Ethyl Corp.*

1766. Sonic Thickness Tester
Measurement of wall thickness from one side by sonic method. *Branson*

1767. Spark Testing
20-page spark test guide features spark diagrams of 13 standard tool and die steels. *Carpenter Steel*

1768. Spectrograph
New 8-page booklet on optical emission, direct reading spectographs for production control and research. *Applied Research Labs.*

1769. Spectrographic Equipment
20-page catalog describes large Littrow spectrograph, medium quartz spectrograph and densitometer for spectrum analysis. *Bausch & Lomb*

1770. Springs
"Metal Minutes" tells how leaf springs are made at Stanley Spring Works. *Sunbeam*

1771. Stainless Fastenings
20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fitting and specialties. *Star Stainless Screw*

1772. Stainless Steel
Reference Chart lists chemical analyses, physical properties and recommended applications for 28 different grades of cast stainless steel. *Cooper Alloy Foundry*

1773. Stainless Steel
Slide chart. Set top at a certain fabricating operation, bottom shows rating of each standard grade. On reverse side, heat treating and corrosion data are given. *Carpenter Steel*

1774. Stainless Steel
Selector gives machinability, physical and mechanical properties, corrosion resistance of various grades of stainless steel. *Crucible Steel*

1775. Stainless Steel
36-page bulletin on effect on properties of processing at different temperatures. *International Nickel*

1776. Stainless Steel
Bulletin gives examples of five types of stainless steel castings. *Steyer*

1777. Stainless Tubing
6-page reprint "Tips on Stainless for Aircraft Hydraulics". Design and fabrication. *Superior Tube*

1778. Steels for Agriculture
20-page book on steels used in agriculture. *Crucible Steel Co.*

1779. Steel 52100
Data sheet on high-purity 52100 steel, made by vacuum melting. *Vacuum Metals*

1780. Subzero Freezer
Data on chest for use down to −95° F. for production use and testing. *Revco*

1781. Subzero Treatment
12-page bulletin on subzero treatment of tool steel and increase in tool life resulting. *Cincinnati Sub-Zero Products*

1782. Tanks & Linings
16 pages of data on tanks and corrosion-resistant linings for cleaning and plating solutions. *Chemical Corp.*

1783. Temperature Control
36-page bulletin P 1245 on new electronic instruments for recording and indicating variables. *Bristol Co.*

1784. Temperature Controller
Bulletin 6430 on new dual temperature controller, for measuring, indicating, and controlling two temperatures. *Minneapolis-Honeywell*

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BARBER COLMAN

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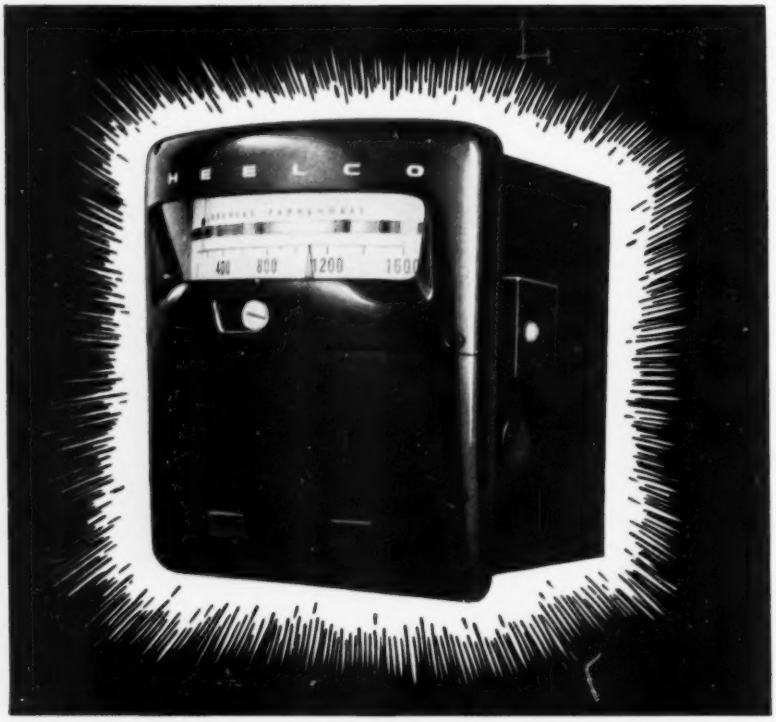

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WHEELCO INSTRUMENTS DIVISION

BARBER-COLMAN COMPANY, DEPT. F, 1518 ROCK ST., ROCKFORD, ILLINOIS

Industrial Instruments • Automatic Controls • Air Distribution Products • Aircraft Controls • Small Motors
Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

4. Vacuum Metallizing
rint "High Vacuum Metallizing of s and Plastics". *Consolidated Vac- Corp.*

5. Vacuum Metallizing
uum metallizing TV picture tubes is ibed in "Stokes News". *F. J. Stokes ine*

6. Vacuum Metallurgy
cles on commercial vacuum fur- for metals and alloys and some as- of vacuum melted metals. *National rch Corp.*

7. Weld Design
ler on how to control production through use of welding. *Lincoln ic*

8. Welding
ge bulletins on recently devel- Fillerarc consumable-electrode gas- ed welding process. *General Elec-*

9. Welding
klet on recent applications of flash ng to ferrous alloys and stainless. *son Electric Welder*

0. Welding Equipment
alog on Cadweld process and arc- ng accessories. *Erico Products*

1. Welding Rods
ge bulletin on bronze welding rods. gives ASTM, AWS and Govern- specifications. *Titan Metal*

2. Welding Stainless
age manual on welding processes ainless with recommendations and s for arc, spot and pulsation weld- Soldering and brazing. *Republic*

3. Wire Baskets
age book on fabricated baskets for ng and heat treating. *Cambridge Cloth*

4. X-Ray Diffraction
letin 8A-3505 on film or direct re- ng X-ray diffraction apparatus. *X- Div., General Electric*

5. Zirconium
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1785. Tempering
Data on rotary tempering units. *Metalwash Machinery*

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Bulletin on test units to combine temperature range from +185 to −100° F., relative humidity from 20 to 95%, and altitude simulation from atmospheric to 80,000 ft. *Bowser*

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Common metals and alloys mounted and identified. Photomicrographs, analyses, hardness data for comparison or teaching. *Buehler*

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20-page booklet describes mining of tin and its present use by American industry. *Malayan Tin Bureau*

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Information on "Sure-Wear" process for heat treating high-speed cutting tools. *LR Heat Treating Co.*

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Properties and treatment of general-purpose air-hardening chromium-molybdenum tool steel. *Bethlehem*

1795. Tool Steel Heat Treat
Bulletin 1147EE on electric furnace for heat treatment of high speed tool steel. *Hevi Duty*

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1798. Tubing Handbook
Handbook E-4 on resistance welded steel tubing. *Ohio Seamless Tube*

1799. Tukon Tester
12-page bulletin DH-114 on Tukon micro and macro hardness testers. *Wilson Mech. Inst.*

1548. Stainless Castings
This slide chart gives the chemical composition, minimum mechanical properties and heat treatment for stainless and corrosion resistant, carbon and alloy steel castings. Military, Federal, ASTM, SAE and AISI designations are given for each alloy. *Lebanon Steel Foundry*

1800. Tungsten Carbide Rolls
Bulletin TB-3 on tungsten carbide rolling mill work rolls gives steels satisfactorily rolled, reduction per pass, service life. *Metal Carbides*

1801. Ultrasonic Cleaning
Folder on principles and methods of metal cleaning by application of ultrasonic energy. *Detrex*

1802. Ultrasonic Testing
Bulletin No. 50-105 on application of ultrasonic testing to manufacture, maintenance and quality control. *Sperry Products*

1803. Vacuum Gage
Folder GEC 986 on molecular vacuum gage for measuring pressures without external detectors. *General Electric*

1804. Vacuum Metallizing
Reprint "High Vacuum Metallizing of Metals and Plastics". *Consolidated Vacuum Corp.*

1805. Vacuum Metallizing
Vacuum metallizing TV picture tubes is described in "Stokes News". *F. J. Stokes Machine*

1806. Vacuum Metallurgy
Articles on commercial vacuum furnaces for metals and alloys and some aspects of vacuum melted metals. *National Research Corp.*

1807. Weld Design
Folder on how to control production costs through use of welding. *Lincoln Electric*

1808. Welding
Three bulletins on recently developed Fillerarc consumable-electrode gas-shielded welding process. *General Electric*

1809. Welding
Booklet on recent applications of flash welding to ferrous alloys and stainless. *Thomson Electric Welder*

1810. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1811. Welding Rods
6-page bulletin on bronze welding rods. Table gives ASTM, AWS and Government specifications. *Titan Metal*

1812. Welding Stainless
54-page manual on welding processes for stainless with recommendations and settings for arc, spot and pulsation welding. Soldering and brazing. *Republic Steel*

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84-page book on fabricated baskets for dipping and heat treating. *Cambridge Wire Cloth*

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Bulletin 8A-3505 on film or direct recording X-ray diffraction apparatus. *X-Ray Div., General Electric*

1815. Zirconium
26-page booklet gives physical, mechanical and chemical properties, present and potential uses, supply and prices of zirconium. *Zirconium Metals*

June, 1954

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1522	1548	1574	1600	1626	1652	1678	1704	1730	1756	1782	1808
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1524	1550	1576	1602	1628	1654	1680	1706	1732	1758	1784	1810
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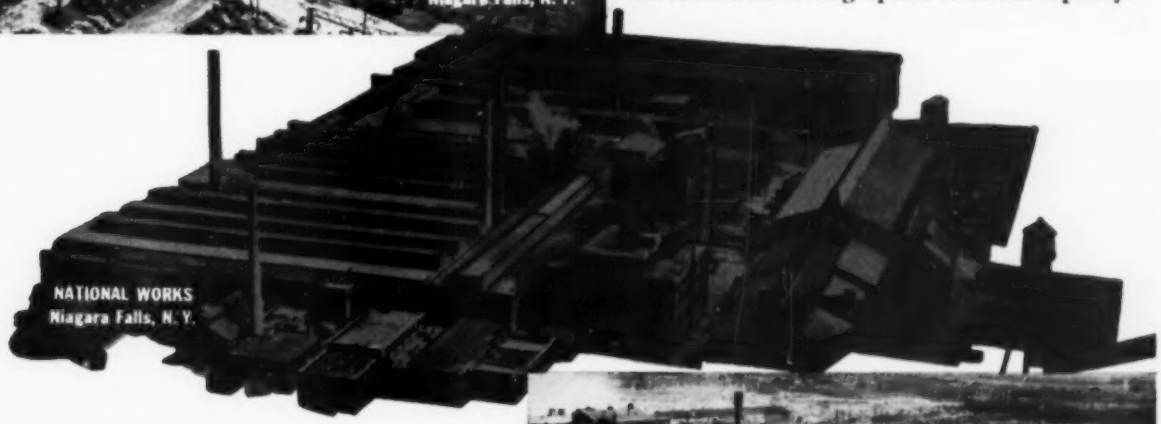
FIVE REASONS WHY NATIONAL CARBON COMPANY ELECTRIC FURNACE ELECTRODES GIVE YOU THE MOST FOR YOUR MONEY...

ELECTRODE QUALITY . . . has a direct bearing on the quality of *your* product; in many instances, it can materially affect your *cost.* National Carbon's graphite and carbon electrodes are, and always have been, the finest quality obtainable *anywhere.* We make this statement without reservation.

NEW PRODUCT DEVELOPMENT . . . is basic in technological progress. National Carbon has *always* done the major part of this country's electrode research and development . . . a share out of all proportion even to its outstanding leadership in the production and sale of these products. This is a matter of long-standing record.

PLANT CAPACITY . . . National Carbon's ability to *produce* is at an all-time high. The five plants shown here are fully integrated for production of both carbon *and* graphite electrode products — a situation rare in the industry and in keeping with National Carbon's far-sighted planning to pace requirements of a rapidly-expanding economy. For example, plant additions in the last five years alone have more than doubled graphite electrode capacity.



EXPERIENCE . . . of National Carbon is the foundation, building blocks and cornerstone of electrode-products manufacture in this country. First with commercial production of both carbon and graphite electrodes in the early 1900's, National Carbon introduced the first of each increasingly larger electrode size from that time to the present, plus a host of successful accessory items for improved application of electrodes in the metallurgical field. Today, National Carbon is the only company producing carbon electrodes up to 45″ diameter; graphite electrodes to 35″. Even larger electrodes and other massive shapes can be made with present facilities. Inquiries are invited.

RESPONSIBILITY . . . to customers and to the industry as a whole . . . expresses itself several ways in National Carbon history. The company has consistently kept ahead of demands for both quality and size of electrode products; National Carbon research stands virtually alone in the steady march of new product development; and, in the field of *service,* National Carbon is supreme. For many years we have conducted an expanding, electrode technical-service operation, staffed by a group of electrode experts, specially trained to help you get *more for your electr de dollar.*

The terms "National" and "Acheson" are registered trade-marks of Union Carbide and Carbon Corporation

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A Division of
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Here's how you save

WITH THE

DU PONT SODIUM HYDRIDE DESCALING PROCESS

1. SHORT TIME CYCLE

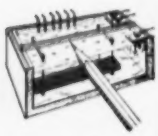
Only 15 seconds are required to get cold reduced-annealed strip clean and bright—10 to 20 minutes for fabricated articles, sheets, wire, rods, bars and forgings. Even heavily scaled forgings (½" scale thickness) take less than an hour!

2. NO LOSS OF BASE METAL

There's no danger of costly rejects due to pitting, etching, or loss of gauge with the Du Pont process—no matter how long work is left in the bath. This permits working to closer tolerances and assures high dimensional accuracy.

3. RETREATMENTS RARELY NEEDED

One pass through the sodium hydride bath will do the job completely. You can maintain uniform speed in production-line descaling. Quick completion of orders means you can substantially cut down on inventory in process.



4. SIMPLIFIED PROCESS

No scale-breaking or special racking procedures are required. Finished stock of any size or shape can be completely descaled with the versatile Du Pont process. Even dissimilar metals can be treated in the same bath—at the same time!

5. EASY TO OPERATE

Any pickler can be trained in a few hours to run the Du Pont Sodium Hydride Descaling Process effectively. You can do more work with fewer men and less equipment. And you save on time, space and labor costs.

6. DU PONT TECHNICAL SERVICE

If you are descaling metals which are unaffected by fused caustic at 700°F., it will be to your advantage to talk with us about the Du Pont Sodium Hydride Process. Du Pont pioneered this modern descaling method and can bring a depth of technical experience to bear on your descaling problems. There's no cost for this service which includes laboratory investigation of problems plus expert aid in the construction, installation and operation of the process. Just call our nearest district office or send in the coupon below.

SEND FOR FREE BOOKLET describing the Du Pont Sodium Hydride Descaling Process—how it works—what it can do for you. This illustrated booklet lists the metals that can be descaled with this remarkably efficient process . . . gives brief descriptions of necessary equipment and operating precautions. Just fill out and mail the coupon below for your copy. E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Department, Wilmington 98, Delaware.

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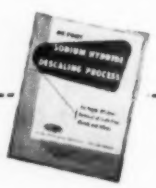

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☐ Please send me your free booklet on Sodium Hydride Descaling.

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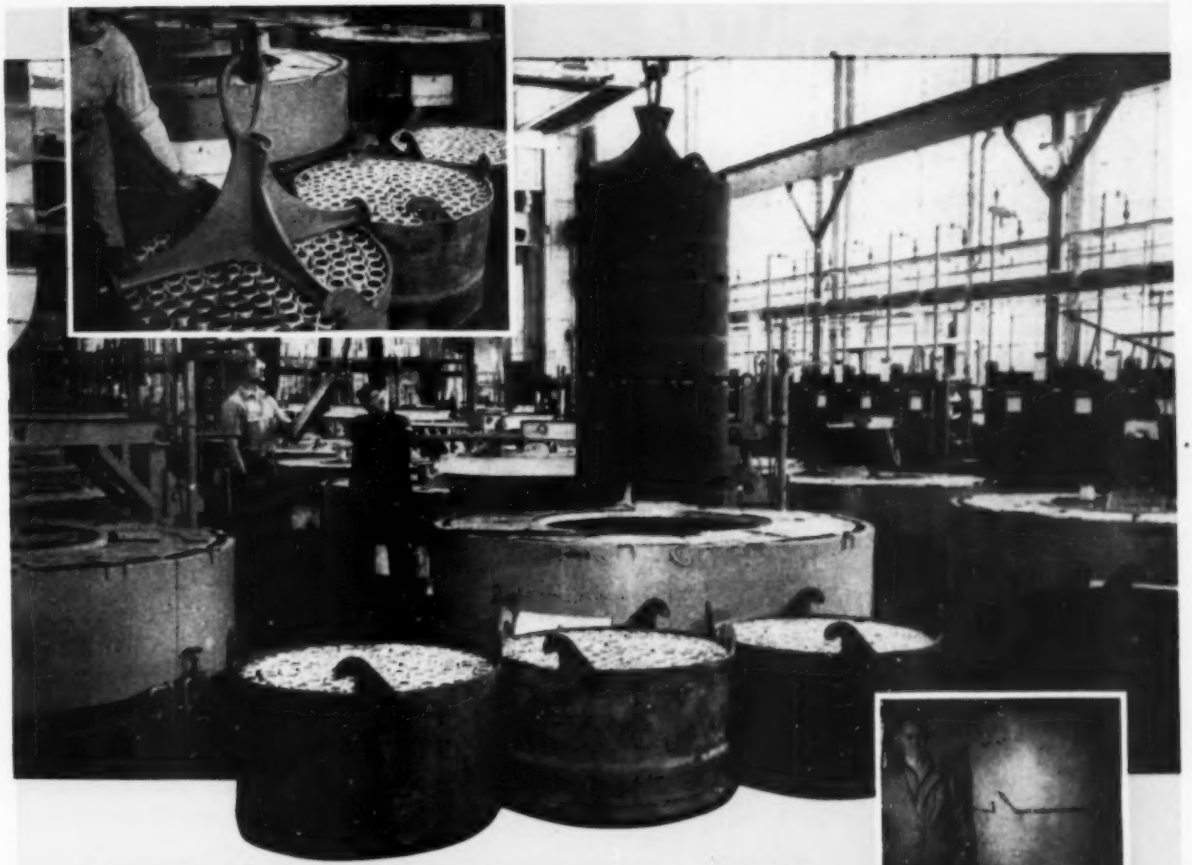

CATERPILLAR TRACTOR CO. MOVES 4½ TONS IN A SINGLE LOAD!

"WHAT'S so unusual about moving four and a half tons?" Nothing . . . except at CATERPILLAR TRACTOR CO., Peoria, Illinois, where track bushings are carburized at 1700° F. in a pit type furnace . . . 3½ net tons at a time.

This is accomplished with the use of alloy baskets designed by ACCOLOY ENGINEERS in collaboration with Engineers of CATERPILLAR TRACTOR CO. and produced in the plant of ALLOY ENGINEERING & CASTING CO., Champaign, Illinois.

Each basket shown above is 37" diameter by 22" deep and when fully loaded contains over one ton of track bushings. With a complete load of three baskets, the gross weight is in excess of four and a half tons.

Outstanding design features of these baskets are (1) uniform metal sections throughout (2) ration of pay-load to alloy weight is over 3.3 to 1. (3) simplified interlocking of baskets results in easy loading and unloading (4) basket grids designed to give uniform flow of carburizing gas through dense load (5) grids designed for reversibility. Original baskets are still in use after 2½ years. Here again is a notable example of a tough job that was effectively solved by engineering skill and co-operative effort between the supplier and user.

We welcome the opportunity to work with you on your High Temperature problems. Consult your nearest ACCOLOY Engineer without obligation and discover why these quality castings are "preferred by industry."

HEAT RESISTANT CASTINGS
ACCOLOY
STAINLESS STEEL CASTINGS

ALLOY ENGINEERING & CASTING CO.

ALLOY CASTING CO. (Div.)
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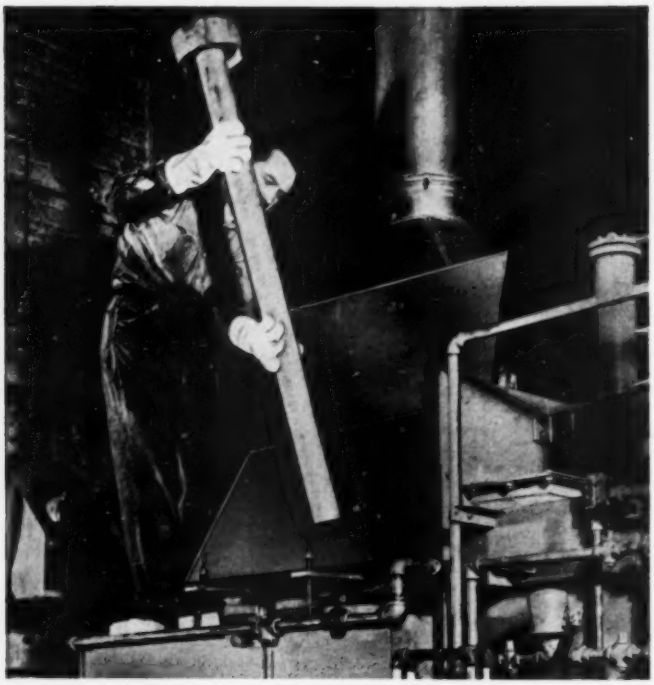
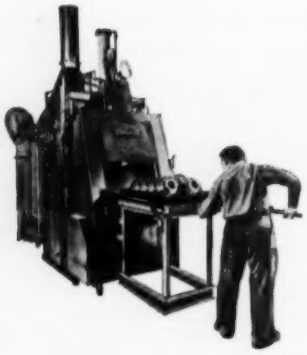
ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

Inconel radiant tubes in new Lindberg multi-purpose furnace come out on top!



Time for a Change? It's no job at all to slip one of these thin-wall Inconel vertical tubes into the new Lindberg Carbonitriding Furnace. The tube collar, which forms a heat seal, is shaped from Inconel sheet and welded to the tube. These lightweight tubes transfer heat efficiently, yet give long service life because of Inconel's resistance to oxidation and many corrosive atmospheres at high temperatures.



You would hardly believe that replacing a radiant tube could be this simple — *but it is!*

In the carbonitriding furnace recently developed by the *Lindberg Engineering Company*, of Chicago, all you do is lift out the old tube and hang a new one in its place.

Inconel® tubes like the one shown above weigh only 29 pounds.

Yet they are sturdy and long-lasting. They resist oxidation and many corrosive furnace atmospheres at high temperatures. They must, for tubes really get a workout in this furnace! Lindberg designed it to handle not only carbonitriding, but hardening, carburizing, annealing and carbon restoration as well. Different furnace atmospheres are supplied by an adjustable generator.

Inconel takes all of these varying conditions in stride. It resists cracked ammonia and carbon monoxide atmospheres, and provides excellent strength throughout the entire carbonitriding temperature range. Its good strength persists at temperatures up to 2,200°F. Also, it is readily workable and can be welded by ordinary shop methods.

You can see, then, why Lindberg has standardized on Inconel tubes for their new furnace.

To learn how Inconel can serve you in troublesome high-temperature applications, write for a copy of the booklet, *Keep Operating Costs Down . . . When Temperatures Go Up.* It's yours on request.

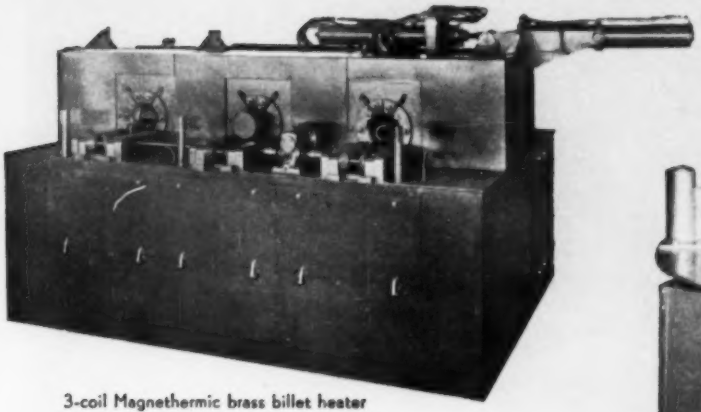
THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO

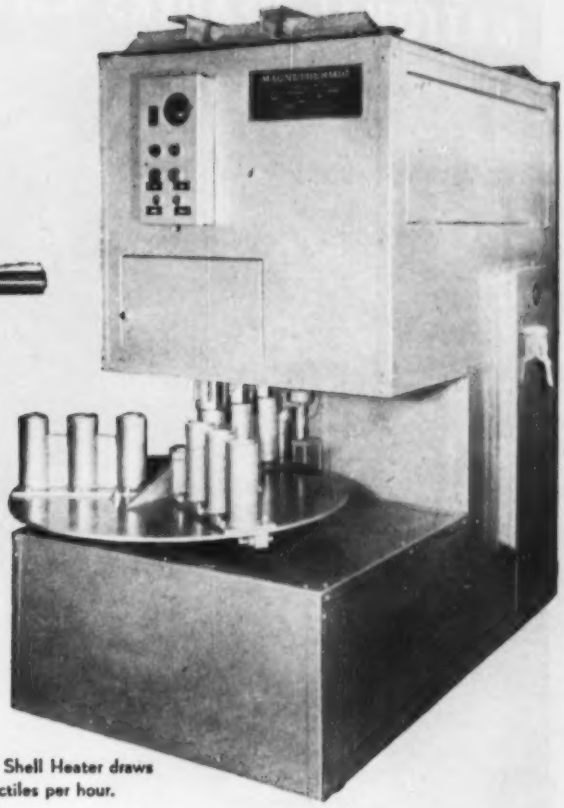
Inconel... *for long life at high temperatures*

Why, Where, How and Wherefores...

of low-frequency
(60-cycle) induction heat



3-coil Magnethermic brass billet heater is rated at 8,000 pounds per hour.



This Magnethermic Shell Heater draws 200 (75 mm) projectiles per hour.

HERE'S THE WHY

Rapid and penetrating heat ... preheating an 8″ dia. copper or brass billet in less than two minutes ... on a production basis. Temperature of each billet is measured. Cold or over heated billets cannot reach the press. No need to schedule billets ahead of time. A Magnethermic Heater is always ready to go without warm-up time. Press the button and you have a hot billet immediately.

HERE'S THE HOW

You require a heater with either single, double or three coils, depending upon your production. A Magnethermic engineer will come to your plant and outline what you need and answer any of your questions. Setting up for low-frequency (60-cycle) heating is not complicated. Installation can be made in a matter of hours and floor space is at least a third less than for conventional furnaces.

HERE'S THE WHERE

Use this penetrating heat for preheating, prior to hot working such as forging or extruding. You can heat rounds, squares, hexes ... in lengths from slugs up to long bars. The diameter range: Steel (carbon or stainless) above 4″ dia.; Brass above 2″ dia.; Aluminum above 1″ dia.; Titanium above 4″ dia.

For example, this method has proved successful for annealing steel parts or preheating gears prior to shrinking or hardening.

HERE'S THE WHEREFORE

The Magnethermic heats scale-free. An added incentive—this heat can be accomplished inexpensively in an inert atmosphere. Magnethermic has pioneered the use of low-frequency (60-cycle) induction heating and has installed most of the heaters in use. Much research on low-frequency (60-cycle) induction heating has been done in Magnethermic's research laboratories. Use this experience to help you decide which is the best heating method for your production.

60-CYCLE
MAGNETHERMIC
corporation
INDUCTION HEATING
3990 SIMON R... YOUNGSTOWN 7, OHIO

Your inquiry ...
If you want information on a Magnethermic Heater for your plant, let us know what size billet you intend to heat; for what use; and desired production rate. Your inquiry will receive prompt attention.

This efficient and highly productive Header Department of The American Screw Company, Willimantic, Connecticut . . . 116-year-old leading producer of Wood, Machine, and Tapping screws with either Phillips Recessed or Slotted Heads . . . produces thousands of gross of fasteners daily.

American Screw relies upon its large batteries of National Cold Headers to give day-after-day quantity and quality production.

If you have a forging problem . . . large or small, hot or cold, ferrous or nonferrous . . . let us help you solve it. Send us prints, or a sample part, or better yet, visit us. No obligation.

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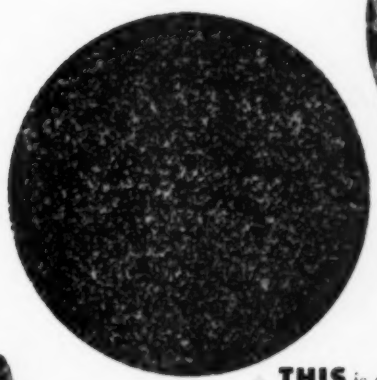
DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES • MAXIPRESSES • REDUCEROLLS • COLD HEADERS • BOLTMAKERS • NUT FORMERS • TAPPERS • NAILMAKERS

Hartford Detroit Chicago

You don't need 3-D glasses

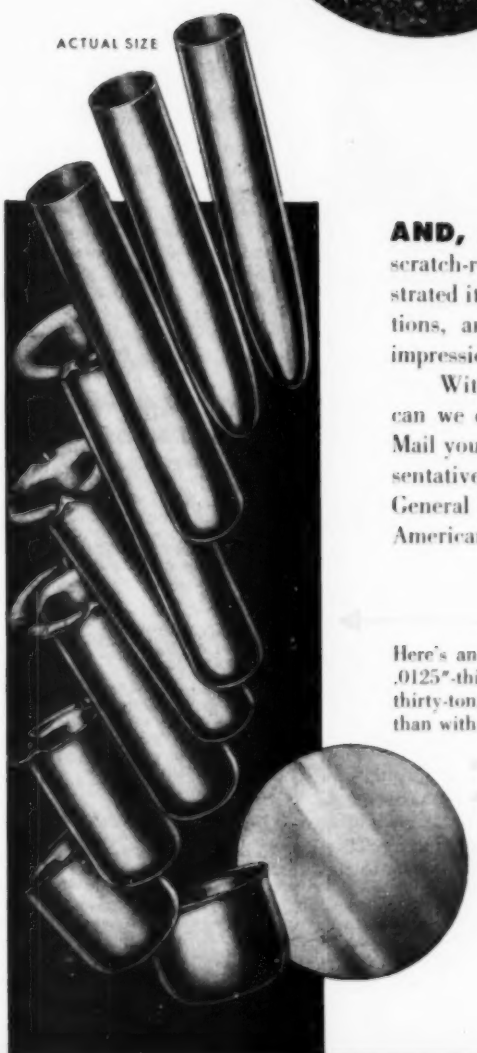
to see the difference



THIS is a 75X magnification of ordinary drawing brass—the kind that's been used for decades for stamped or drawn brass products.

THIS is a 75X magnification of super-fine-grain Formbrite.* Isn't it obvious that this new type of brass can be polished in half the time? Frequently, a simple color buff will bring up the desired finish for lacquering or plating.

ACTUAL SIZE



AND, Formbrite is harder, stronger, springier and more scratch-resistant than ordinary drawing brass, yet has demonstrated its remarkable ductility for forming and drawing operations, and ability to take sharp, clean-cut ornamental die impressions.

With all these advantages, Formbrite costs no more. What can we do to help you try this time and cost-saving metal? Mail you a booklet? Send you a sample? Ask our Sales Representative to call? Simply write to The American Brass Company, General Offices: Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario, Canada.

*Reg. U. S. Pat. Off. 5486

Here's an example of Formbrite at work. These pen caps are made of .0125"-thick Red Brass Formbrite strip at the rate of 2,000 an hour on a thirty-ton, 10-step multiple plunger press. Caps are buffed at a higher rate than with any other metal previously used.

Formbrite DRAWING BRASS

an ANACONDA® Product

made by The American Brass Company

UNICHROME
Trade Mark

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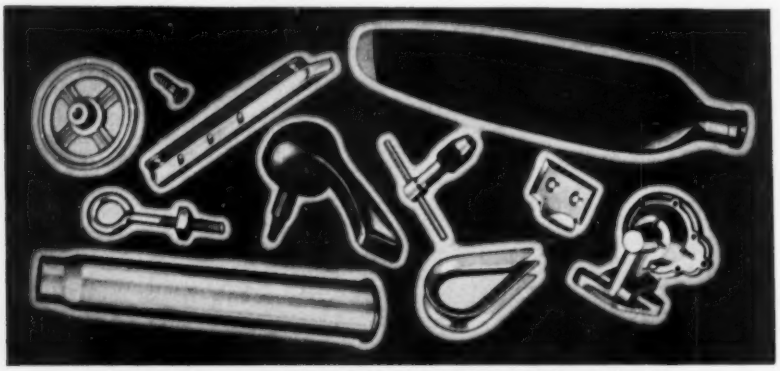
COATINGS for METALS
Metallic . . . . . Organic . . . . . Decorative . . . . . Protective

Extra opportunities to cut costs with zinc finishing

Wider choice of corrosion resisting chromate finishes being offered



Some of the many products finished in Unichrome Dips or Anozinc

CHROMATE treating still remains one of the best ways to finish zinc die castings or zinc plated steel. It strengthens corrosion resistance. It's an *easy* way to finish. It's economical. And time has proved its quality.

With such a combination of virtues offered in a finish, it pays designers, metal finishers and production men to review their products—and to evaluate the benefits of chromate finishing against their finishing requirements. Especially today—when the pressure is on to cut costs every possible way.

Through the unusually wide choice of finishes United Chromium provides, even greater benefits become possible. Here's why. A more economical dip solution may be chosen. Or a production advantage may be realized.

FOR EXAMPLE:

The right Unichrome Dip meant half the material consumption and longer solution life to one company.

Brighter finish on zinc plated hardware with less solution-waste was gained in another plant with still another compound.

Chromate treating of zinc plated steel shell cases done electrolytically with Anozinc is found best and cheapest in the long run by many producers.

HERE IS VARIETY

Unichrome chromate finishes offer a good color choice. Lustrous, clear bright finish or black—brassy yellow or olive drab—even brass-color—all these can be produced chemically by Unichrome Dip solutions.

Unichrome chromate finishes also satisfy production method requirements. Compounds are available for manual or automatic operation.

An exclusive electrolytic process, Anozinc* rounds out this complete line of conversion coatings. It's found especially economical in continuous, large run automatic production. This process permits finished parts to be handled while wet.

Write for more data. **Trade Mark*

66% more chromium plating with same current source

One company, only able to plate *six* bumper bars per load, made a tremendous improvement by means of a simple change. They merely switched to a Unichrome SRHS Chromium Solution—and found that *ten* pieces of work per load could be covered with fewer rejections, all without any need for a larger current supply. That's good proof of the better coverage, higher efficiency and greater economy that "SRHS" offers. Write for Bulletin SRHS-2.

Sprayable plastisol builds up thick coating without sagging

First successful sprayable vinyl plastisols, the Unichrome Series 5300 Coatings can be applied even to vertical cold metal surfaces without sagging. Cured coating film up to 25 mils thick can be produced in a single application. Now even large areas can get the amazing protection against corrosion and wear offered by these non porous, chemical resisting, chip-proof coatings. Send for Bulletin VP-1.

HELPFUL HINTS
by "Mr. Cost Cutter"

For true economy in an organic finish, base your specifications on both quality and applied cost—rather than on misleading cost-per-gallon. Consider 3 flat black finishes for wrought iron, for example:

	applied cost/sq. ft.
Coating "A"	1.2 to 1.3¢
Coating "B"	0.8 to 0.9¢
Coating "C"	0.8 to 0.9¢

A Unichrome epoxy resin type finish, Coating "C" sells for twice as much per gallon as the other two, yet it not only gives best "mileage" but also a better looking, more durable and corrosion resistant finish.

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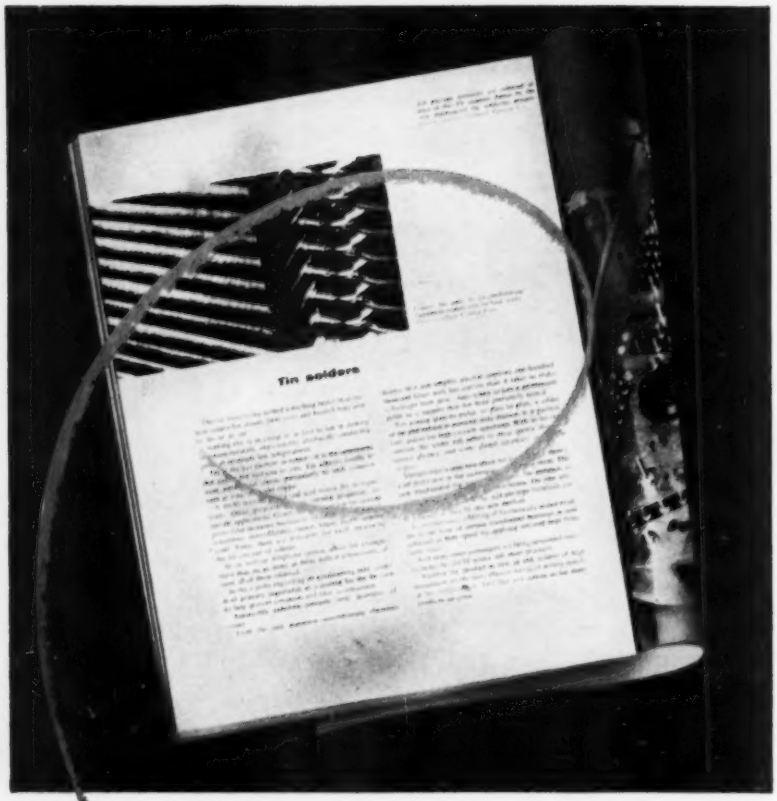


NEW BOOKLET ON
STRAITS TIN FROM MALAYA

This new booklet describes the many ways Straits Tin—in new solders, new alloys, and new platings and coatings —is now being used to make better products at lower cost. It is factual, informative — and could well prove profitable to you. Write now for "Straits Tin: A Most Useful Metal for American Industry."

New Tin Alloys—New Techniques Make Soldering Faster, More Efficient

They've been using tin-rich solders for almost 2000 years — and haven't found a real substitute yet. Nothing else is as cheap or as easy to use in making corrosion resistant, impermeable, electrically conductive joints at relatively low temperatures.

Making Solder Still More Efficient

Now, new alloys and new soldering techniques are making tin solders still more useful on production lines.

A solder of tin-indium, for example, is now used for sealing glass to metal or glass to glass. It will adhere to mica, quartz, thermosetting plastics, and some glazed ceramics, as well.

For joining aluminum, cerium added to a tin-rich, tin-zinc solder gives both improved salt spray resistance and better wettability.

New techniques for applying solder include ultrasonic methods of soldering and tinning aluminum, and the new mechanized dip soldering process that is saving industry thousands of man-hours.

Tin is, of course, the key ingredient in solder. Over one-third of the world's tin is mined and smelted in Malaya. Known as Straits Tin, this metal is more than 99.87% pure and is world-famous for its absolute reliability of grade.

A New Look at Straits Tin

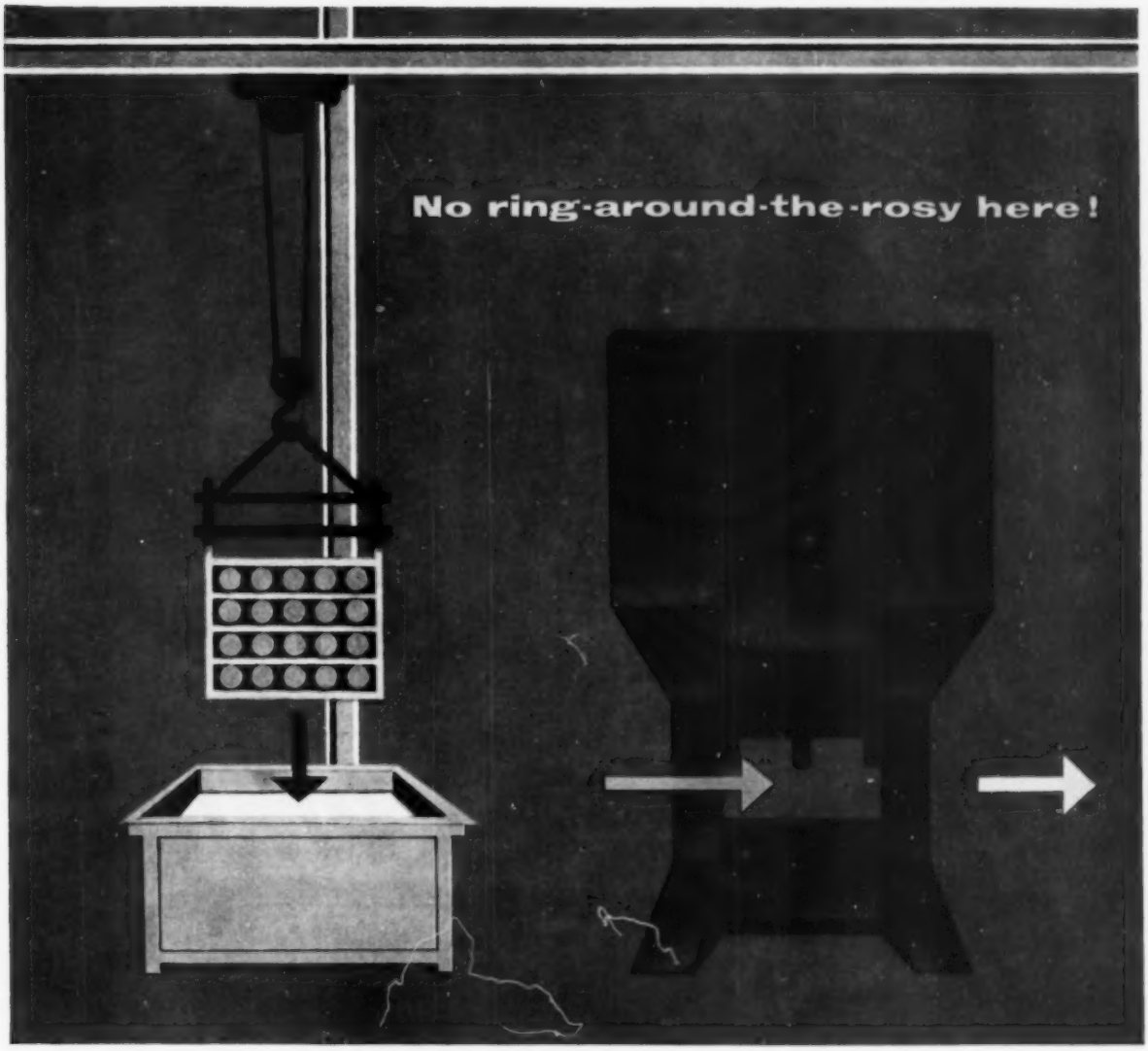
Today, not only new solders but new tin alloys, new tin-alloy coatings and platings, and new uses for tin chemicals make Straits Tin more valuable than ever to American industry. And continuing research will, in the near future, find still more ways in which tin can serve you.

Whatever your product or process may be, now is the time to reappraise carefully the unique combination of properties of Straits Tin. For no other metal we know today can do so many different kinds of jobs so economically and so well.

THE MALAYAN TIN BUREAU

Dept. 353, 1028 Connecticut Ave., Washington 6, D.C.

MALAYAN TIN BUREAU



With the new Pennsalt Fos Process, cold steel can be extruded into finished shapes . . . directly . . . with important economies in manufacturing. Cold steel discs or billets are formed into shafts, cylinders, tubes, gear blanks and many other parts in the press. This eliminates up to 80% of all machining . . . creates a direct line manufacturing system that lowers costs and improves production.

The Pennsalt Fos Process is now being used in automotive, tube, wire drawing and ordnance plants. The process includes a new Pennsalt lubricant and a proven method of locking that lubricant to the steel. The Fos Process insures the smooth and rapid flow of cold steel through the die, even at extreme pressures.

Practically all the original metal can be utilized with Pennsalt cold extrusion techniques . . . work cycles can be reduced . . . and over-all production speeded up. Superior physicals can be obtained from carbon steels, along with a better, smoother finish. Multiple draws without interim recoating and annealing, and greater reductions per draw are now practical.

Is Fos Process practical for your plant . . . your products? Send us details of desired application, or blueprints of products. We will be glad to evaluate possibilities. Customer Service Department, 523 Widener Building, Philadelphia 7, Pa.

Pennsalt Chemicals

THE PENNSYLVANIA SALT MANUFACTURING COMPANY

your best buy for all your metal degreasing

and here's why!

ALL-PURPOSE—Removes from metal parts practically every kind of foreign matter—waxes, oils, greases, gums, tars, chips.

QUICK ACTING—Cleans and dries rapidly. Low boiling range (86.6°-87.8°C, based on standard ASTM tests) permits vaporization at low steam pressure.

THOROUGH—Low viscosity (0.58 centipoises at 20°C) and low surface tension (about 29 dynes per cm at 30°C) assure diffusion into pores and relatively inaccessible openings.

SAFE—Has neither flash point nor fire point; classed as nonflammable at room temperatures, only moderately flammable at higher temperatures (Underwriters' Laboratories rating 3).

CUTS POWER CONSUMPTION—Can be heated by either gas, steam or electricity. Gives concentrated vapor at only 188°F. Specific heat less than ¼ that of water.

CUTS VAPOR LOSS—High vapor density (4.5 times that of air) assures proper vapor level at all times.

STABLE—Neutral stabilizer gives protection not only in the liquid but also in the vapor.

ECONOMICAL—Completely re-usable after distillation. And whether you buy by the drum or the carload, *you pay no extra premium.*

A request, written on your company letterhead, will bring you a free copy of our new Nialk TRICHLOR*ethylene booklet.*

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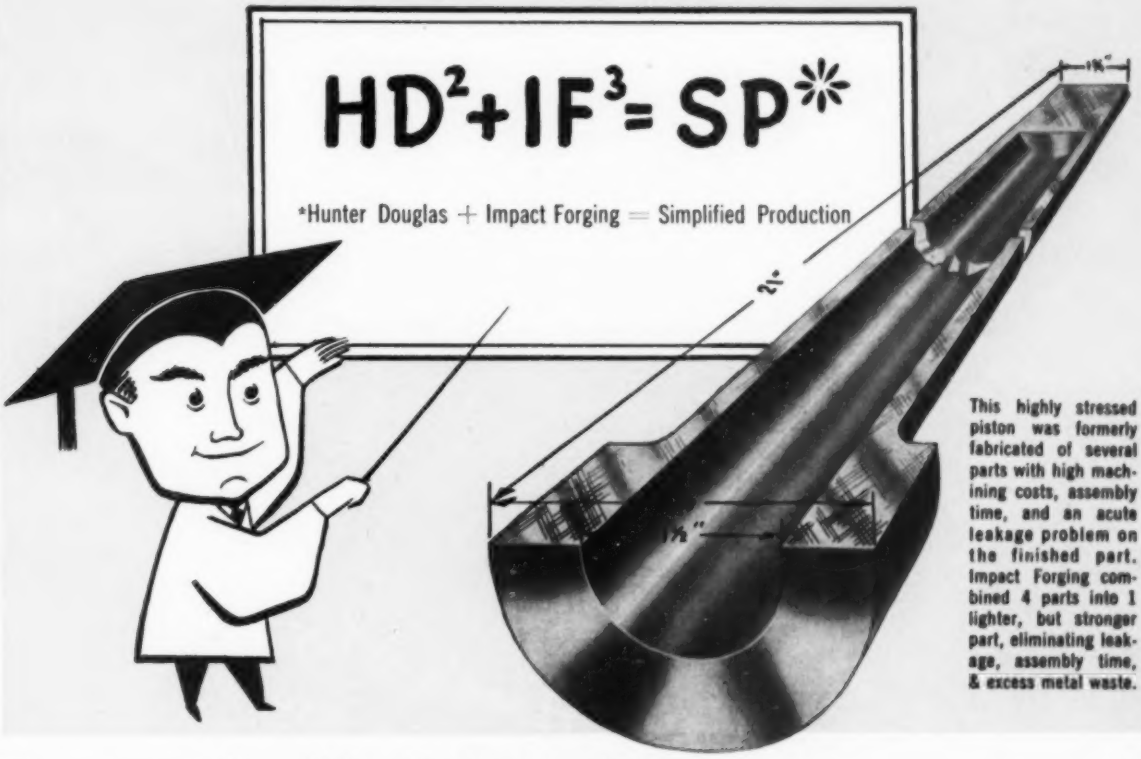
Mr. Design Supervisor

...an equation you should know



This highly stressed piston was formerly fabricated of several parts with high machining costs, assembly time, and an acute leakage problem on the finished part. Impact Forging combined 4 parts into 1 lighter, but stronger part, eliminating leakage, assembly time, & excess metal waste.

You can simplify design with...

IMPACT FORGING

FROM

HIGH STRENGTH ALUMINUM ALLOYS

Impact Forging is a mass production method of shaping high strength aluminum alloys by direct compression. This new production technique, perfected by Hunter Douglas, permits the use of heat treatable aluminum alloys in applications formerly designed to steel. Combined with the strength-weight ratio of aluminum, Impact Forging develops a forged grain flow to obtain maximum strength in each part.

Impact Forging can often produce the same part in one operation that formerly required multiple machining, and produce as a single piece a part that under ordinary methods required a number of smaller pieces assembled by threading, welding, or other secondary operations.

If you are designing a part for mass production with close dimensional tolerances and micro-precise surface finish, Impact Forging can be your answer. Hunter Douglas has had a vast amount of experience in making millions of high strength aluminum alloy forgings with great economies through simplified design. Find out how you can design for Impact Forging in place of machining, drawing, forging or casting. Forward your blueprints, specifications, or sample parts and let the Hunter Douglas engineering staff give you their analysis.

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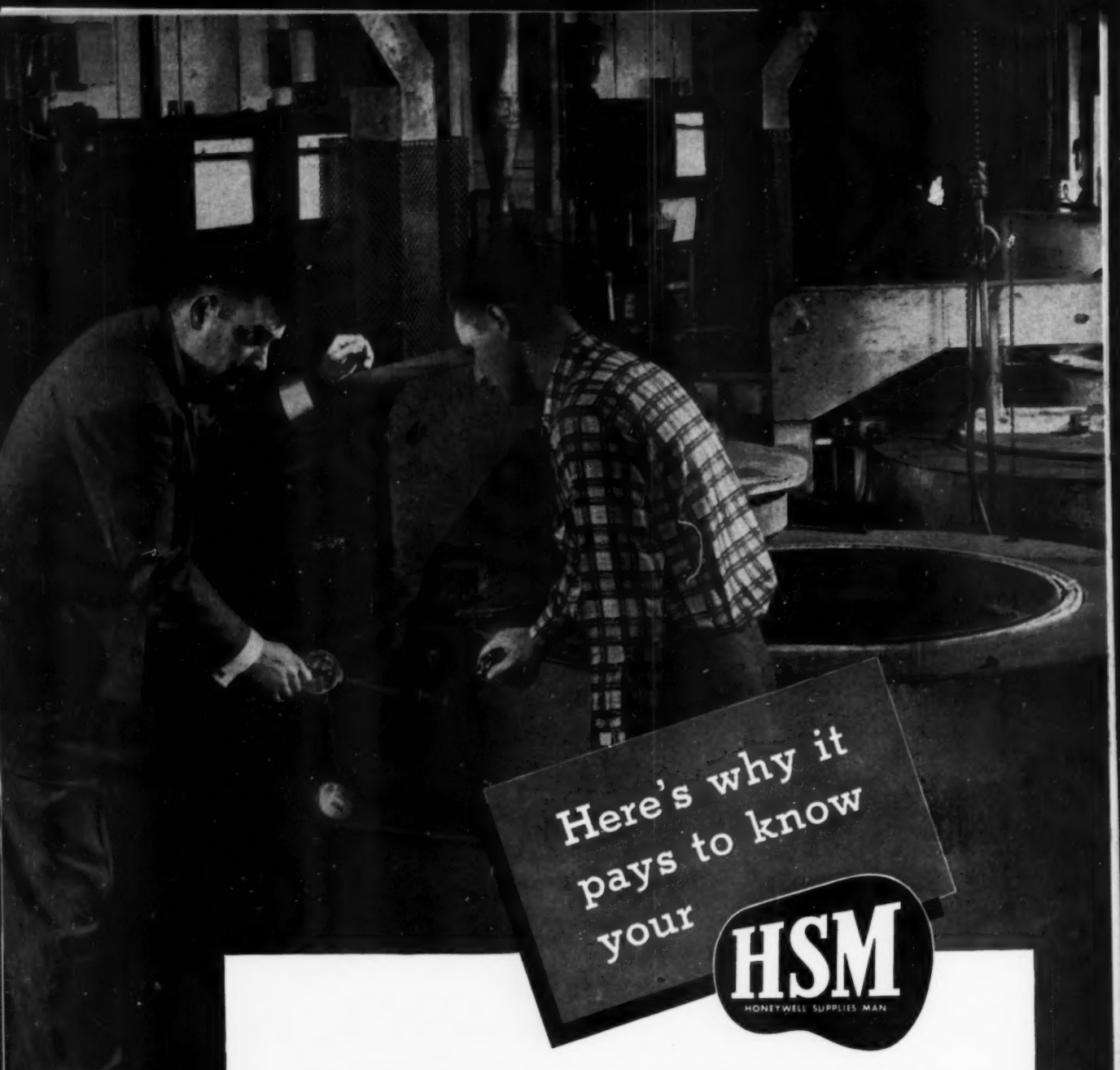

Here's why it pays to know your HSM

HONEYWELL SUPPLIES MAN

J. F. KRAMER, HSM (Honeywell Supplies Man) in the Cleveland area, points out features of the Brown Thermocouple Head to Al Shuba, Instrument Repair Group Leader at Jack & Heintz Inc. . . . shows how the all-weather design prevents corrosion, freezing and rusting.

Personalized, expert service . . . by full-time specialists in pyrometer supplies . . . is the keynote of the HSM Plan. This unique plan can bring new economy, convenience and quality standards to all your purchasing of pyrometer supplies.

Your nearby HSM will be glad to discuss how planned buying—the HSM way—can save time and money for you. He'll draw up an individually fitted program for your specific needs. Call him today . . . at the Honeywell office nearest you.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA:**
Write for Pyrometer Supplies Buyers' Guide No. 100-5.

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First in Controls

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LOW TEMPERATURE SILVER BRAZING ALLOY

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ADJUSTABLE-DIAMETER CALIPERS

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PLUNGER IS BUTT BRAZED TO SHANK

Continuous grinding gages made by Arnold and distributed by Federal "take the gamble out of grinding" by automatically controlling dimensions. They are helping many manufacturers to speed and simplify cylindrical grinding operations and to eliminate waste caused by undersize rejects and oversize regrinds.

Silvaloy Low Temperature Brazing Alloys and APW flux are used in the manufacture of these gages, to be certain of strongest possible construction and trouble-free performance. Some of the Silvaloy-brazed points are shown here.

Low Temperature Silvaloy Brazing is helping to speed production, lower costs and improve results for manufacturers in many fields. Call the Silvaloy Distributor in your area for information—or ask him for technical assistance. A Silvaloy Technical Engineer will be sent to your plant, at once, without cost or obligation to you. ★ ★ ★ ★

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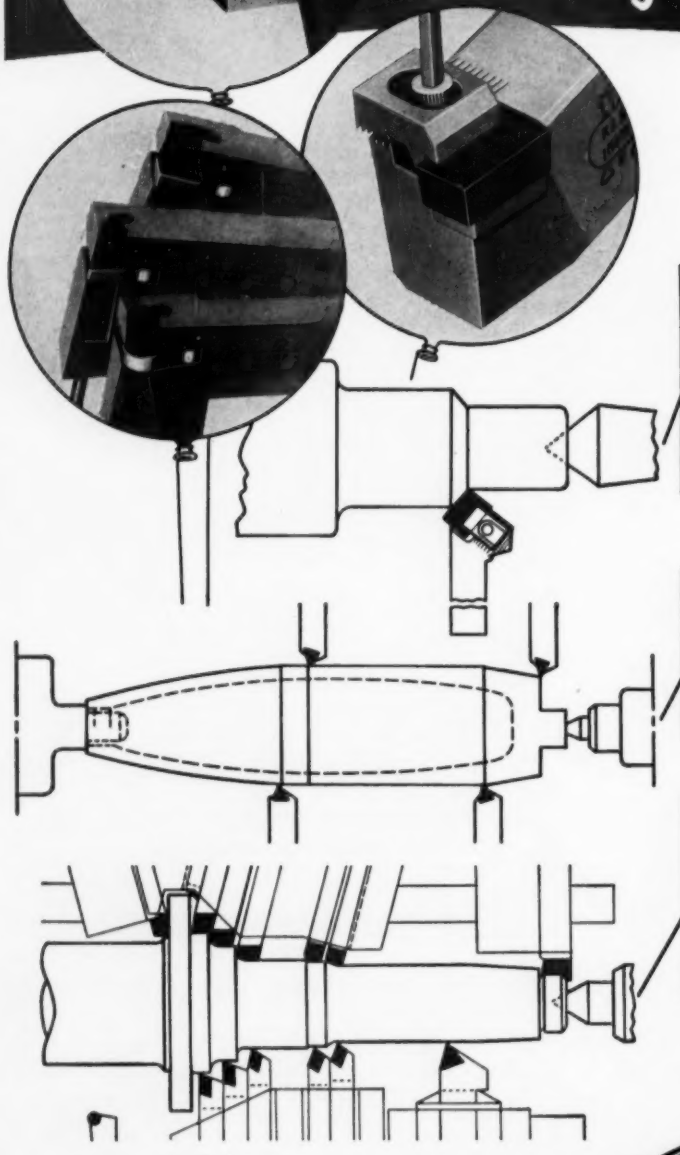

USERS REPORT SUPERIOR RESULTS

LARGE PITTSBURGH ROLL FOUNDRY

PART	SAE 52100 forged chrome steel mill roll 28" O.D.
OPERATION	Rough turn and finish machine roll necks and barrel.
MACHINE	48" x 15' Mackintosh-Hemphill Lathe, 50 H.P. motor drive.
TOOL	H-Style Klamp-Lok Toolholder with horizontal clamped Talide insert—Grade S-88 for roughing —Grade S-92 for finishing.
DEPTH OF CUT	¾" for roughing cuts. ⅛" for finishing cuts.
FEED	.050
S.F.M.	125 to 210
RESULTS	Talide tools held cutting edge 40% longer per grind than previous grade used — even at temperatures of 1700° F!

LARGE CHICAGO SHELL PLANT

PART	105 M/M (M-1) H.E. Shell.
OPERATION	Rough turn shell body, 1050 Steel Forging.
MACHINE	12" x 21" Fay Automatic Lathe.
TOOLS	TB-16 Triangular Talide Inserts with 3/32" radius vertically clamped in Klamp-Lok Toolholder Grade S-92.
DEPTH OF CUT	⅜"
FEED	.035
S.F.M.	325
RESULTS	45 Shells per grind or 25% increase over previous average of 35 shells.

LARGE MID-WEST TRACTOR PLANT

PART	Shaft Steering Clutch, SAE 8654-H Brinell 370.
OPERATION	Rough Straddle Face Flange, turn all diameters, form undercut and base.
MACHINE	16 x 60 Sunstrand Automatic Lathe.
TOOLS	8 Talide-tipped facing, chamfering, radius and form tools Grade S-88. 7 Klamp-Lok Toolholders with round, triangular and parallelogram Talide inserts Grade S-88.
DEPTH OF CUT	9/32" to 7/16"
FEED	.022
S.F.M.	156
RESULTS	Production up 20% — Scrap and rejects down.

Complete stocks of standard Talide Tools and Tips are immediately available from our warehouses located in Newark, Youngstown, Detroit, Chicago and Los Angeles. Write for General Catalog No. 54-G, Metal Carbides Corporation, Youngstown 7, Ohio.

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TALIDE
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RCA announces revolutionary NEW Electron Microscopes

Now—from RCA, pioneer and world leader in electronic research, come two great new electron microscopes. The EMU-3A with both 50,000 and 100,000 volt accelerating potential is destined to be recognized as *perfection in electron microscopy*—the ideal tool for advanced research requiring highest resolution, maximum magnification and critical control. The EML-1A, a 50,000 volt instrument, has every important feature needed for peak performance in a wide range of research and control functions.

Here are some of the key engineering advances and improvements that make these precision instruments invaluable:

- High resolving power—20 and 30 Angstrom Units
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- Choice of 50,000 volt and 100,000 volt accelerating potential
- Vertical column construction for stability and accessibility
- Single set of pole pieces for all magnifications
- Insensitive to vibration and magnetic fields
- Roll film and plate cameras—choice of four different picture sizes
- External control of objective aperture
- Binocular Viewer
- Large 5" x 5" direct view, high brightness screen
- Push Button Controls—Unusual ease of operation
- Selected Area and Reflection Diffraction

What can these important new instruments do for you?

Factual information on the features, construction and operation of the revolutionary new RCA Electron Microscopes is yours for the asking. WRITE: Radio Corporation of America, Dept. F-72, Building 15-1, Camden, N. J.

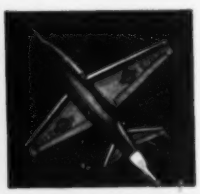
RADIO CORPORATION of AMERICA

How much heat from a "heat" of Chromel?

You've seen molten metal before . . . but chances are you've never seen a "heat" that's more closely controlled as to composition and quality than the one you see above. For this is a heat of Hoskins Chromel . . . the *original* nickel-chromium alloy that *first* made electrical heating practical. Into it go precise amounts of the purest raw materials obtainable . . . mixed, melted, and poured in exactly timed cycles. And from it, ultimately, will come approximately 1200 pounds of fine finished material . . . smooth, bright, durable wire or ribbon produced to a specified resistivity for long, dependable service as heating elements or cold resistors in countless different electrical devices.

Heating elements made of Hoskins Chromel give long life service in industrial electric furnaces, home appliances.

Spark plugs equipped with Hoskins electrode alloys give long dependable service wherever they're used.



Hoskins Chromel-Alumel thermocouple alloys accurately register exhaust temperatures of jet aircraft engines.

Chromel, however, is only one of many specialized, quality-controlled alloys developed and produced by Hoskins. Others include: Alloy 502 . . . used throughout industry for a wide range of heat resistant mechanical applications. Spark plug electrode alloys . . . which have become universally accepted standards of quality and durability. Alloy 717 . . . used in facing engine valves for longer life and improved service. And, of course, there are Hoskins Chromel-Alumel thermocouple alloys for industrial furnaces and jet engines . . . unconditionally guaranteed to register true temperature-e.m.f. values within close specified limits.

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ALUMINUM REPORTER

★ ★ ★ Fourteenth in a Series to Industry on Aluminum Uses and Developments ★ ★ ★

NEW ALL-ALUMINUM MOBILE HOME MAKES NEWS

Aluminum and Plastic Team Up to Make New, Improved Wading Pool

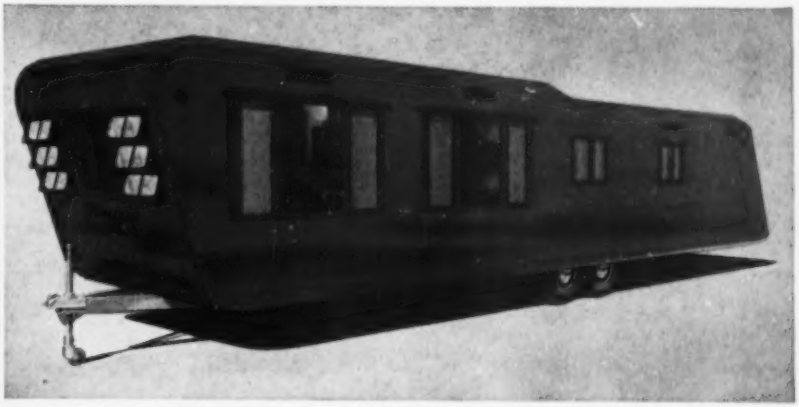
This novel wading pool made by the Ideal Toy Corporation, New York 10, N.Y., offers a good example of design and engineering skill in getting maximum benefit from the right combination of materials in a product. Ideal engineers wanted a sturdy pool—yet one easily inflatable and simple to set up. They found the solution through judicious use of both aluminum and plastic.

Named the "Aquarama," this wading pool features an all-aluminum wall with safety rolled edges and an inflatable one-ring inner liner made of heavy gauge vinyl. The aluminum wall—made of Reynolds Aluminum—prevents loss of water experienced with unsupported depressed sides and also protects the plastic against rough use. This non-rusting aluminum wall rolls into a compact coil around the deflated pool and comes packed in a convenient shipping carton. Pool with Inflato-Pump and other extras retails for under $20.

This Ideal Wading Pool is sold in sporting goods, furniture, hardware and other stores handling children's play equipment. It also is one of the growing number of quality products that carry the new "Designed in Reynolds Aluminum" Seal. For details on how the aluminum products you fabricate can qualify for this seal merchandising program simply write to the address below.

Reynolds design and engineering service is available to all manufacturers, not only those working exclusively with aluminum but also to those who use it in combination with other materials in their products. To get the most from the aluminum you use—alone or judiciously combined with other materials—call your nearby Reynolds Office, Reynolds Distributor, or write Reynolds Metals Company, 2576 So. Third St., Louisville 1, Ky.

Mon-O-Coach "041" Hailed as Major Design and Engineering Achievement in Mobile Home Development



The revolutionary all-aluminum Mon-O-Coach "041" Mobile Home shown above features new monocoque stratoliner construction in which the entire body of Reynolds Aluminum is one strong unit instead of body-on-frame construction. The drawing below shows how extruded aluminum bottom, sidewall and top members make a one-piece riveted unit reinforced with aluminum castings.

Reynolds engineers were asked in by the builder—the Mon-O-Coach Division of Ironwood Trailer Coaches, Inc., Ironwood, Michigan—right at the initial design stage. These Reynolds engineers worked closely with Mon-O-Coach engineers through completion of the job.

According to the manufacturer, Reynolds Aluminum and monocoque construction make this mobile home up to 4,000 pounds lighter—structurally about one-third lighter than conventional trailers—more mobile . . . easier to pull . . . more economical on the road. All-aluminum construction also eliminates any chance of buckling, warping, corrosion and bi-metallic action.

The assistance of Reynolds engineering and styling service is available without obligation to help manufacturers make full use of aluminum's many advantages. For example, aluminum is light but strong . . . is always attractive (frequently without special finishes) . . . has excellent heat and light reflectivity . . . high electrical and thermal conductivity . . . is low in cost and often permits fabrication economies.

Consult Reynolds Aluminum specialists on your next design or redesign project. Call the Reynolds Office or your nearby Reynolds Distributor listed under "Aluminum," in your classified telephone directory, or write direct.

New Reynolds Rotor Metal Used in Induction Motors

Reynolds development work has proved that a new rotor metal of 99.3% minimum aluminum content with a conductivity of 54 to 57% of the annealed copper standard will produce motors averaging as high or higher torque than higher purity, higher conductivity range material.

This apparent contradiction is the result of close control of the alloying elements. When cast in this metal the rotor bars are less apt to pull apart during solidification and cause loss of electrical contact and ultimate loss of torque. Also, the aluminum has less tendency to weld to the laminations and welding that does occur is broken free more easily by subsequent heating.

Prime advantages of die cast aluminum rotors over copper windings for induction motors are lower material and fabricating costs and lower centrifugal forces exerted on bearings during the motor operation. Write for more complete information.

For more complete aluminum design information send for "Aluminum Structural Design" and "Designing with Aluminum Extrusions." Single copies of these handbooks are free when requested on business letterhead. Write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

MORE INTERESTING NEWS ABOUT ALUMINUM ON NEXT PAGE

(Advertisement)

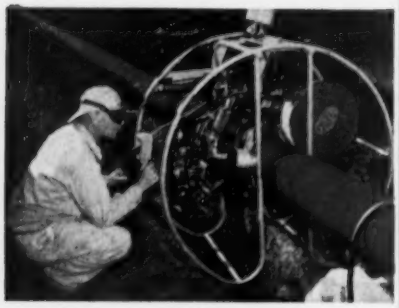
Printed in U.S.A.

(Continued From Preceding Page)

New Automatic Welder Used to Lay Longest Aluminum Pipeline

A new portable automatic welding machine, used during the laying of the longest aluminum pipeline ever installed, welded 40-foot sections of 8⅝-inch aluminum pipe in an average time of four minutes for a five pass weld, compared to about eight minutes or more for welding pipe in place by hand, the method commonly used for steel pipe.

Suspended over the line by a side boom, the automatic welder is equipped with quick-acting clamps which grip the pipe. Pressing a button starts the welding and automatic controls maintain proper conditions of the arc. When the weld is complete, the machine automatically stops, reverses itself, and returns to the starting position. The clamps are released and the machine moves to the next weld.



Welds made during the laying of a 12-mile high-pressure line were subjected to pressure as high as 1800 pounds per square inch, and held firmly. The 40-foot aluminum pipe sections used weigh only 320 pounds while the same size section of steel pipe weighs about 1000 pounds. Reynolds technicians point out that this makes possible savings in handling, equipment and labor which virtually offset the higher cost of aluminum pipe.

The new machine—used in laying the high-pressure pipeline between the White Point gas field near Corpus Christi, Texas and the Reynolds Metals Company LaQuinta alumina plant—was a cooperative development of Reynolds and Air Reduction Sales Company.

Reynolds and Unions Observe "Twenty Years of Harmony"

Production workers in Reynolds Metals Company's Louisville, Kentucky plants recently expressed their appreciation for 20 years of harmonious labor-management relations by presenting a scroll to R. S. Reynolds, Sr., chairman of the Reynolds Metals board of directors and founder of the aluminum firm.

Matt. W. Davis, business agent for Aluminum Workers Local 19388, serving as spokesman for that local and 12 other unions with a total of 2300 workers in the Reynolds Louisville plants, declared: "Our local doesn't have one unanswered grievance. The company very readily sits down and works out any problem it has with a union. It has been about seven years since we had to take a case to arbitration. And we have full employment."

Many Diversified Industries Take Advantage of the Vast Production Facilities Offered by Reynolds Aluminum Fabricating Service

More companies in more industries are taking advantage these days of the facilities offered by Reynolds Aluminum Fabricating Service for producing aluminum parts. Following are some of the reasons why so many companies in both large and small industries are using this service.

First, there are over 200 pieces of major production equipment in two plants alone operated by Reynolds Aluminum Fabricating Service. This equipment includes presses from the very smallest up to presses capable of producing drawn parts 12′ long. Also included are roll forming machines, some of the most modern aluminum welding equipment in the country and some of the most up-to-date automatic anodizing equipment.

Second, Reynolds Aluminum Fabricating Service, because it has produced aluminum parts for diversified industries for many years, has the necessary fabricating experience. Through this experience has been gained a practically unparalleled knowledge of the fabricating of aluminum parts requiring blanking, embossing, stamping, drawing, riveting, forming, roll shaping, tube and shape bending, welding, brazing and finishing.

Third, Reynolds Aluminum Fabricating Service offers important savings to parts customers in many ways. Most important, parts customers do not tie up their capital in raw material inventory and they do not have to buy "specialized" equipment which might be in use only part of the time. Parts from Reynolds are shipped ready to assemble into final products. This also saves on production losses, rejects and scrap handling and storage.

And fourth, Reynolds Aluminum Fabricating Service offers the services of trained engineers who will help in your design problems. To get this design and engineering assistance, simply call your nearby Reynolds Office or write to Reynolds Aluminum Fabricating Service at the address below.

A free 24-page "Catalog of Facilities" is available by writing Reynolds Aluminum Fabricating Service, 2065 South Ninth Street, Louisville 1, Kentucky. Other catalogs covering Appliance Parts and Roll Formed Shapes are also free on request.

New Technical Handbook, "Heat Treating Aluminum Alloys," Now Available From Reynolds

This new 122 page handbook—containing more than 75 photographs, drawings and tables—explains the principles and procedure for heat treating the aluminum alloys.

The book is in three parts. One section presents in easily understood form the metallurgy involved in the heat treatment of aluminum alloys. Another section is of particular interest to the metallurgist and contains data of a more technical nature on both heat-treatable and non-heat-treatable aluminum alloys. A third section presents complete technical processing data in easy-to-follow tabular form.

Single copies of "Heat Treating Aluminum Alloys," are free when requested on your business letterhead (otherwise the book is $1.00). A complete index of Reynolds design, fabrication and application literature is also available. Write to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Aluminum Irrigation Pipe Helps Fight Ground and Forest Fires in Michigan

Aluminum irrigation pipe has been used successfully for water transmission to ground fires by the Department of Conservation in the State of Michigan. They started with 1600 feet of 3-inch aluminum pipe and quick acting aluminum couplers supplied by the W. R. Ames Company, irrigation equipment manufacturers, of San Francisco. When this proved highly successful, additional footage was ordered.

In one ground fire where both aluminum pipe and hose were used, the 1600 feet of 3-inch pipe was loaded on a trailer by four men in just thirty minutes while it took five men two hours and twenty minutes to load 2000 feet of 2½" hose. In addition, four men were kept busy for an entire eight hour day to uncouple, dry, clean and roll the hose—another case where aluminum irrigation pipe saved time and labor.

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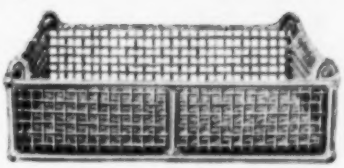

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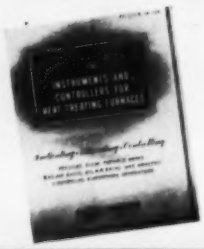

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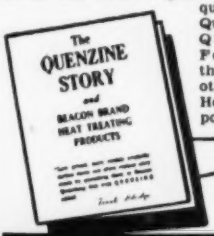

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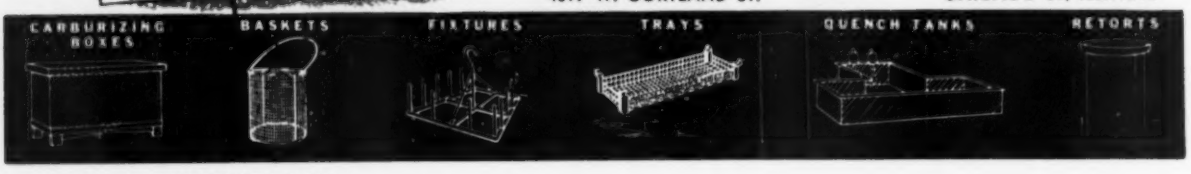

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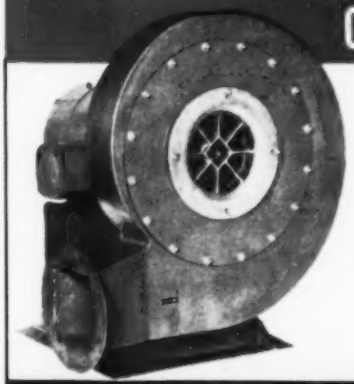

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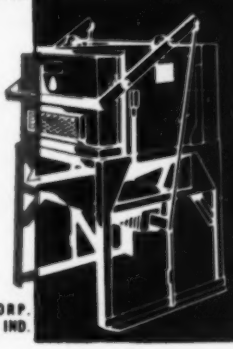

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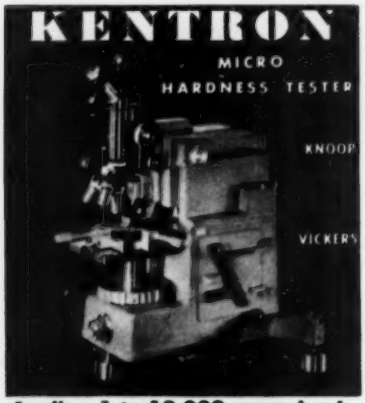

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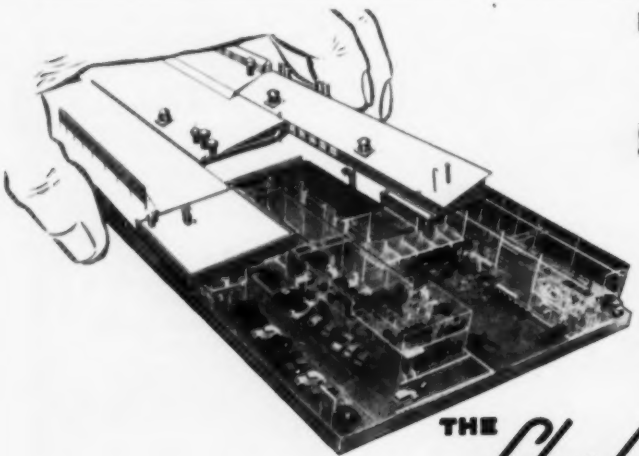

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Electronic Equipment for non-destructive production inspection of steel bars, wire rod, and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.

Over 50 steel mills and fabricators are now using this equipment.

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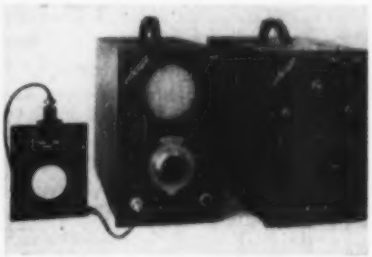

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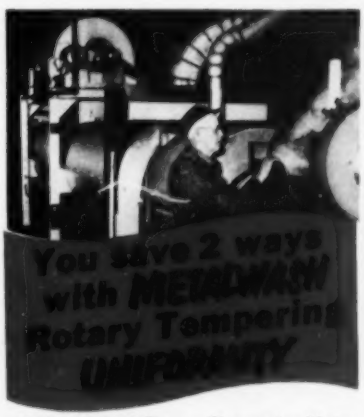

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METALWASH tempering units are *continuous machines:*

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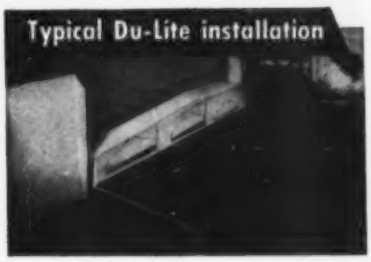
On any steel blackening problem

DEPEND on DU-LITE for a Superior Finish

Courtesy The Poly Choke Co.

Du-Lite gave this part with its complicated knurls, slots, threads, etc. a fine rust-resistant durable black finish. It is typical of many other parts, small and large, which have been black oxidized by Du-Lite for many years. Moreover, Du-Lite meets most individual and government specifications including 57-0-2C for Type III Black Oxide finish.



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METAL FINISHING SPECIALISTS

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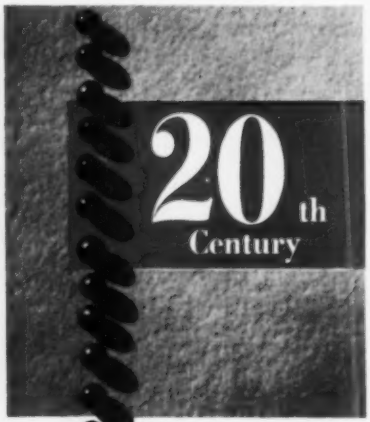

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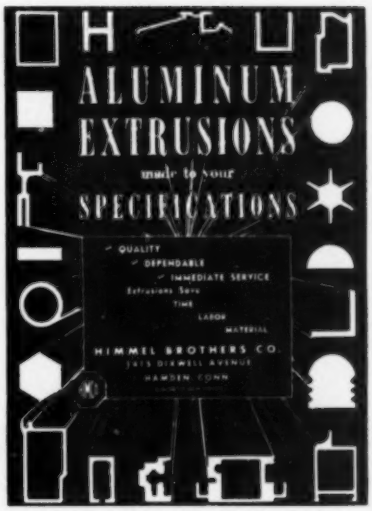

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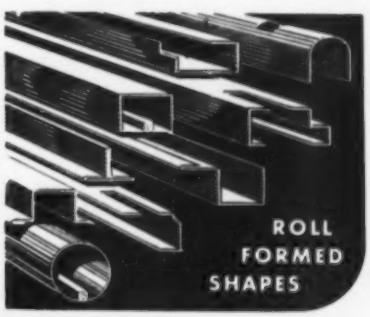

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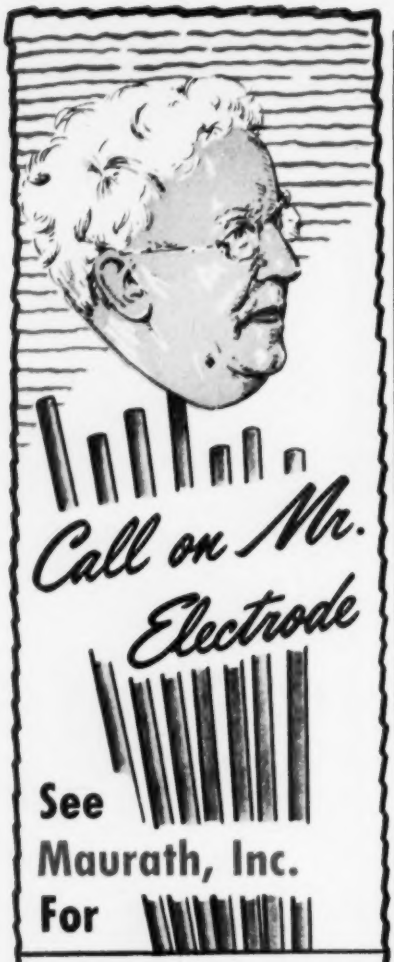

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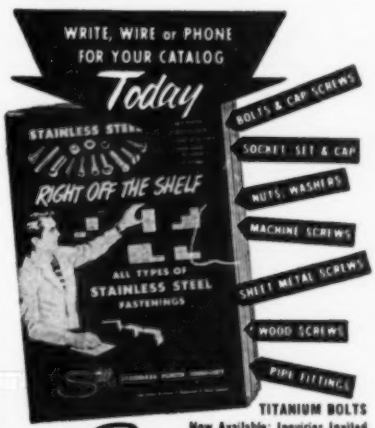

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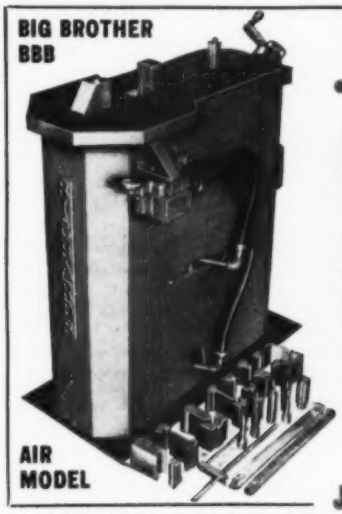

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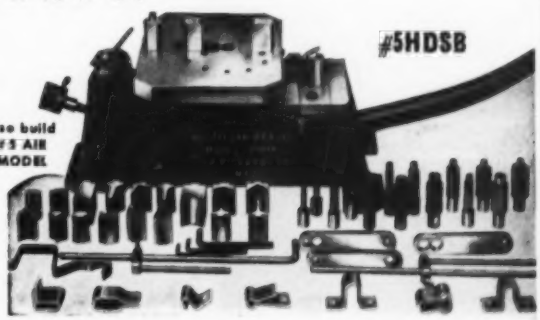

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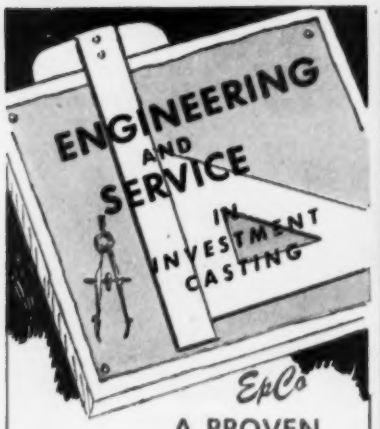

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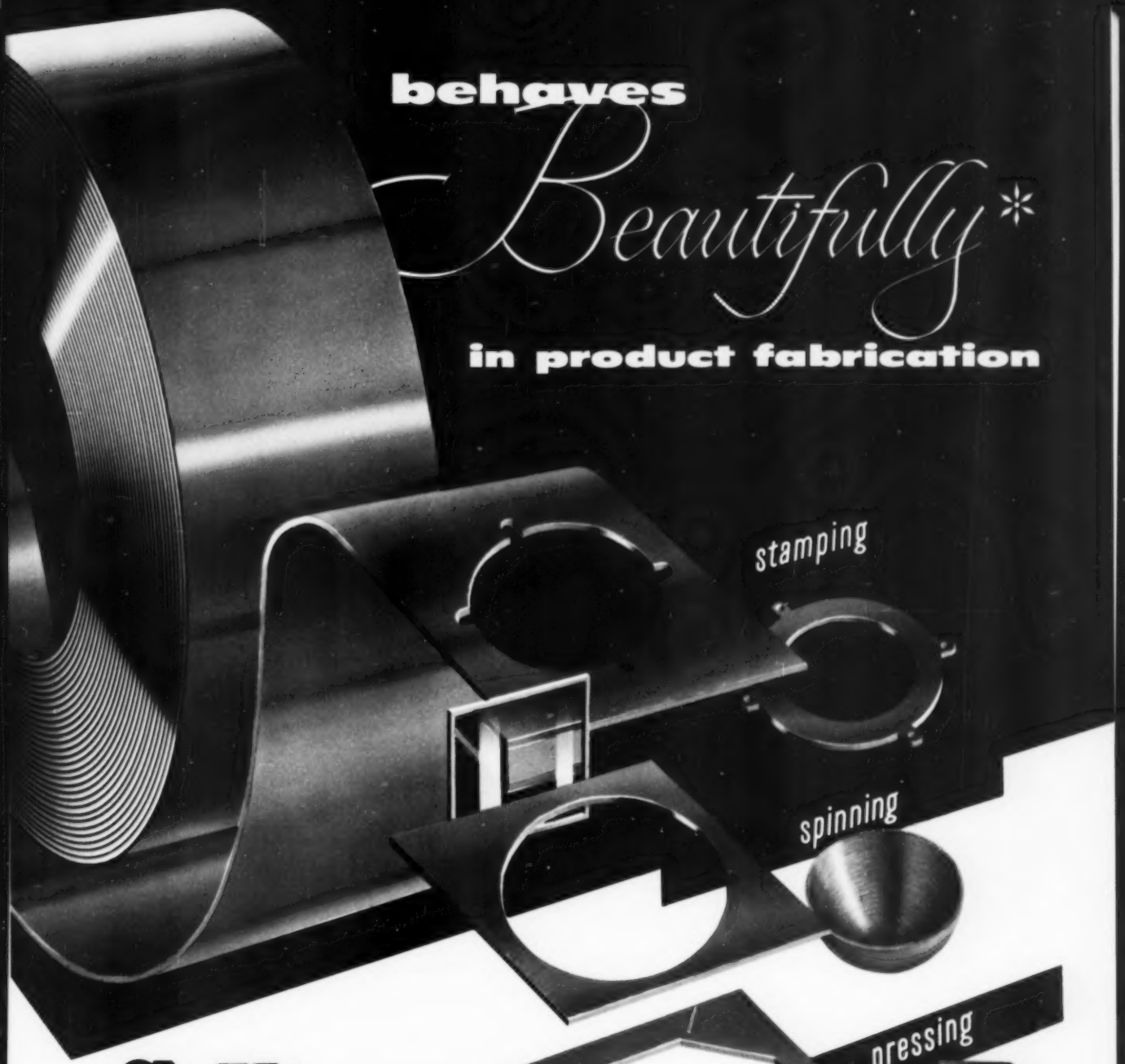

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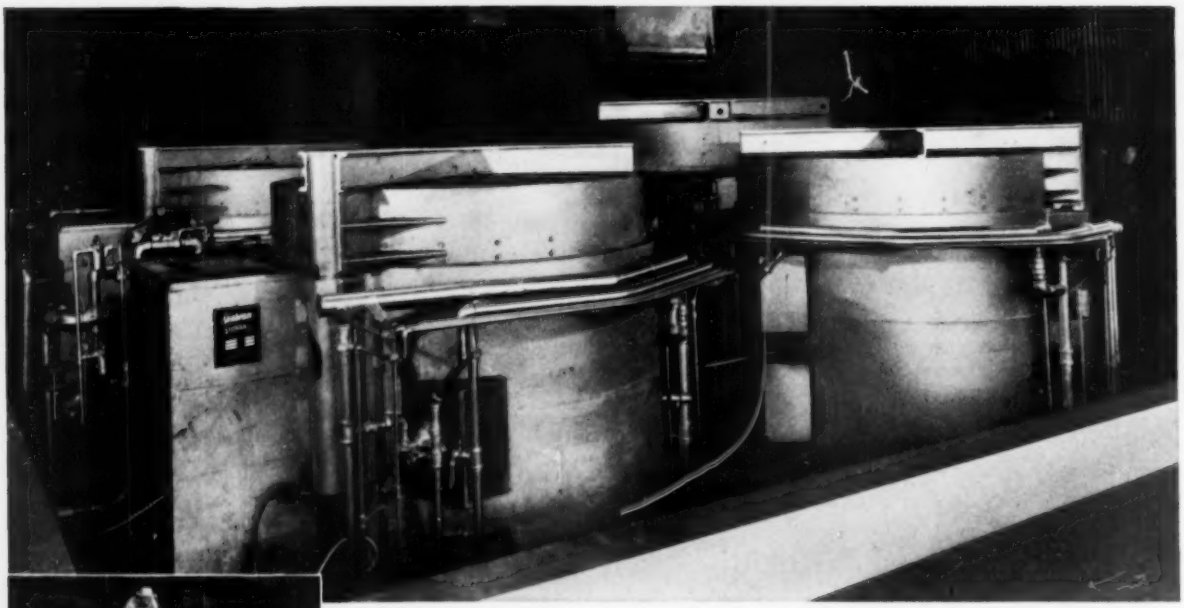

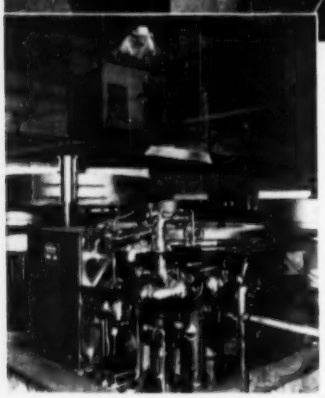

Workman removing a cast steel railroad wheel from one of the four Sunbeam Stewart Furnaces. Capacity of each heat treat furnace is between 18 and 20 wheels, each weighing approximately 600 pounds.

This Sunbeam Stewart heat treating installation consists of four direct fired furnaces having a usable pit depth of 13 feet. Griffin Wheel's method of manufacture and heat treatment has provided a wheel of high wear resistance, high strength and impact values and excellent resistance to fatigue. This program of development in perfecting the new wheel required over ten years.

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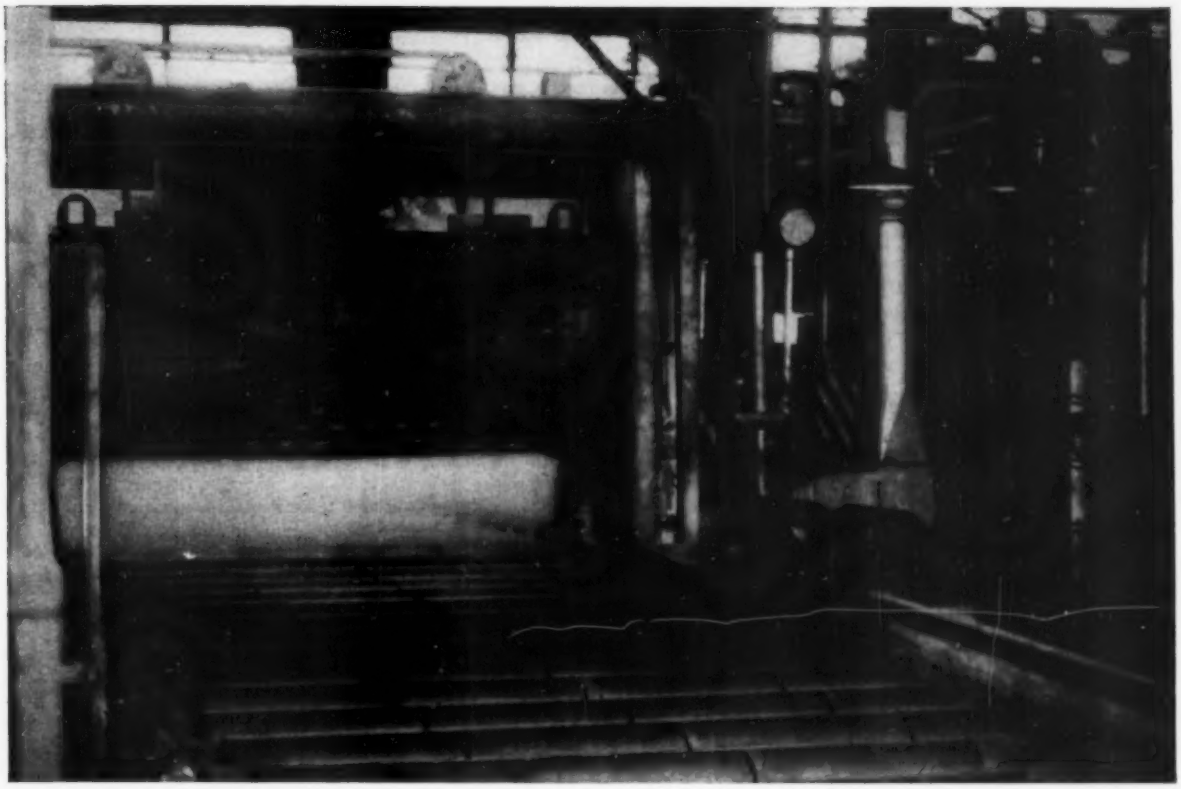

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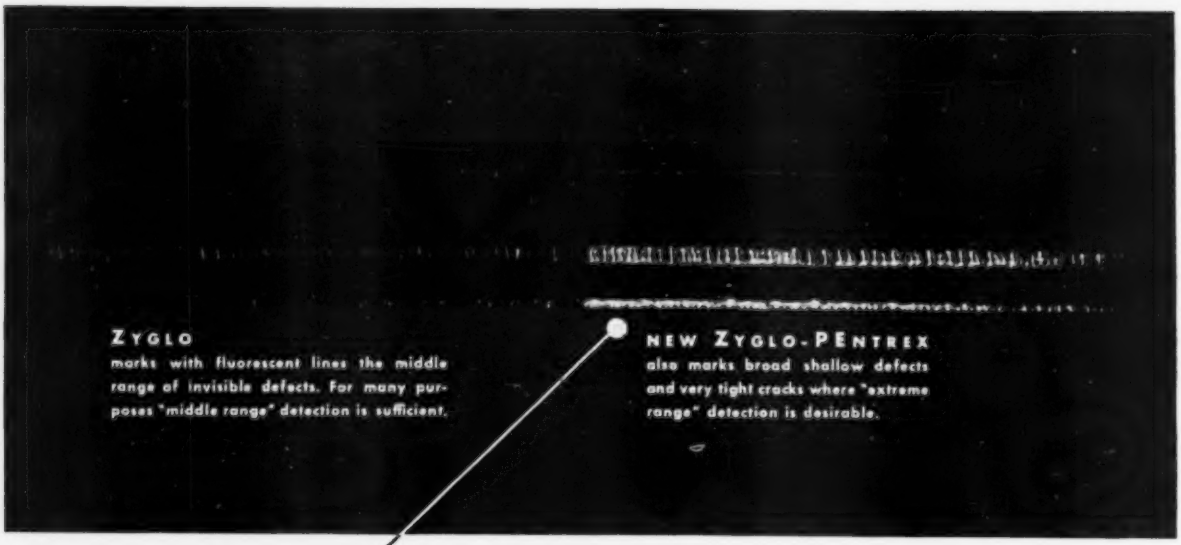
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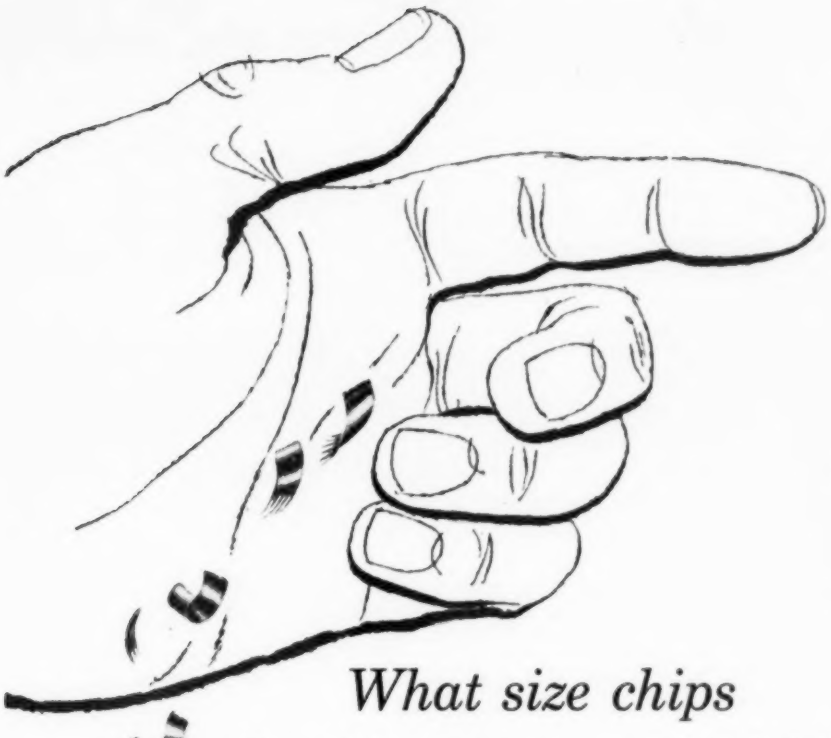

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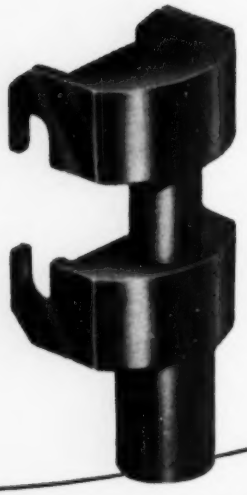

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Arwood has pioneered again — recognizing the need for investment castings free of surface decarburization, Arwood is the first foundry to install carbon restoration equipment.

NOW...

Carbon and low alloy steel investment castings (1020, 3120, 4130, 4140 and 6150) can now meet all of the most exact metallurgical specifications — including freedom from surface decarburization.

Let ARWOOD *help YOU*

solve your production problem — improve your design — save you money — assure you top quality. Drop us a line to have one of our field engineers call on you and discuss how you can best utilize Arwood investment castings.

For the RECORD

These two mating units, pilot and anchor for aircraft clamp ring fastening screw, were previously milled from bar stock.

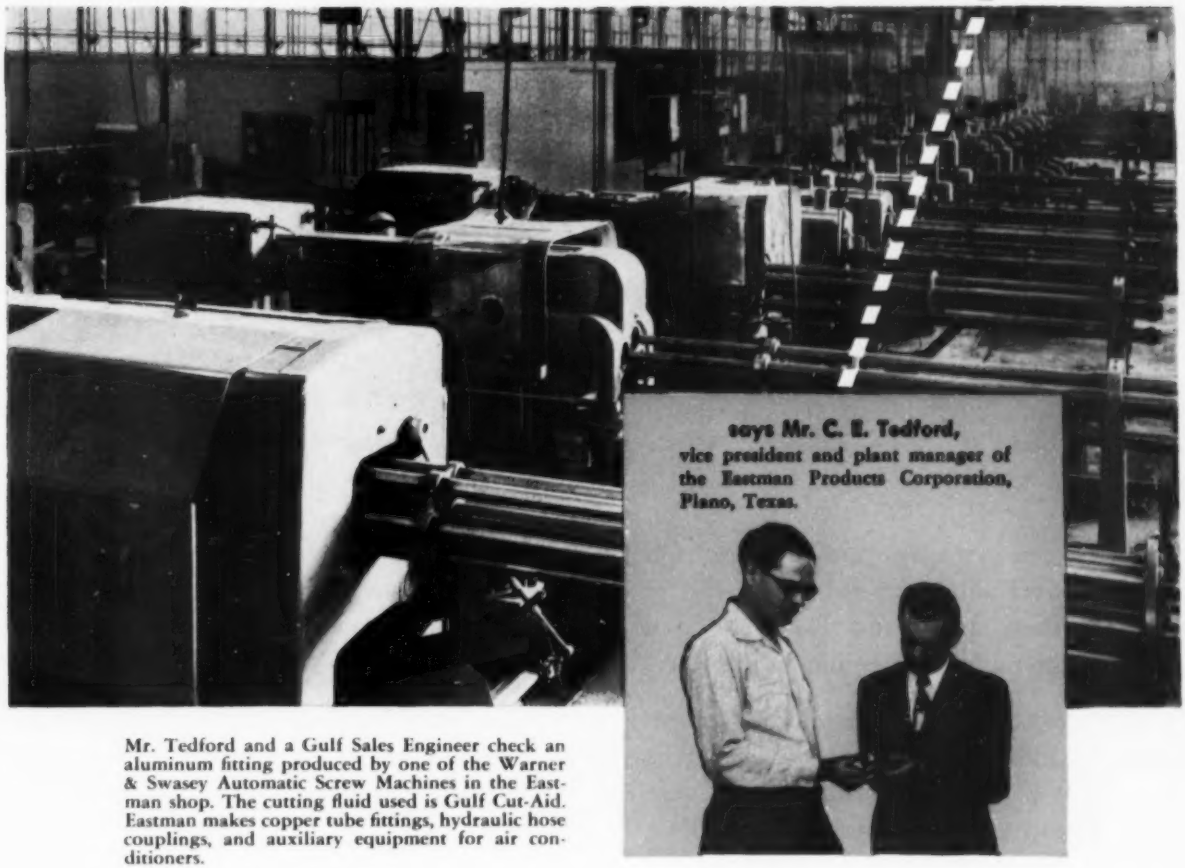
Using the carbon restoration unit, Arwood was able to meet the strict metallurgical specifications necessary to assure dependable performance.

ALLOY: 4140 (.001" Max. Decarb.)
HEAT TREAT: Double normalize, carbon restore, quench, temper
HARDNESS: Rc 25 Max
COST: 22.5% of machined cost

ARWOOD

PRECISION CASTING Corp.
73 WASHINGTON STREET B'KLYN 1, N. Y.
Plants: Brooklyn, N. Y. · Groton, Conn. · Tilton, N. H. · Los Angeles, Cal.

"TOOL LIFE UP 400%
PRODUCTION UP 50%
WITH GULF CUT-AID"



Mr. Tedford and a Gulf Sales Engineer check an aluminum fitting produced by one of the Warner & Swasey Automatic Screw Machines in the Eastman shop. The cutting fluid used is Gulf Cut-Aid. Eastman makes copper tube fittings, hydraulic hose couplings, and auxiliary equipment for air conditioners.

A cutting fluid has to be outstanding to increase tool life 400% and production 50%—and that's what Gulf Cut-Aid has accomplished at Eastman Products! You too will discover that Gulf Cut-Aid, when used for machining aluminum, magnesium, and many other nonferrous metals, consistently produces better results—that means lower costs for you.

Here are some of the advantages of Gulf Cut-Aid that make such results possible: high rate of penetration, "wettability," and excellent cooling properties. It quickly covers tool surfaces to provide constant protection. It also contains an effective anti-oxidation additive which helps prevent gum and sludge formation in the coolant system. And it will not corrode or stain metals.

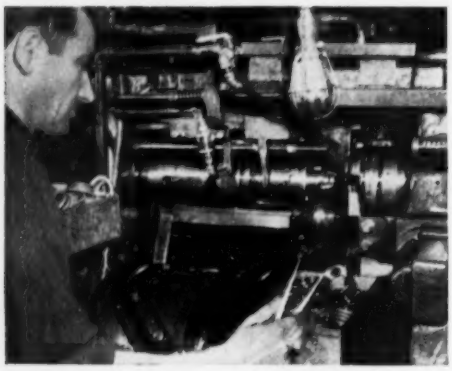
Let a Gulf Sales Engineer assist you in finding opportunities for improved machining practice in your plant through the use of Gulf Cut-Aid. Contact him at your nearest Gulf office today.

Gulf Oil Corporation · Gulf Refining Company

1822 GULF BUILDING, PITTSBURGH 30, PENNSYLVANIA

GULF SERVES INDUSTRY

FREE-MACHINING ENDURO STAINLESS STEEL BARS



Put parts in the pan 90% as fast as Bessemer screw stock

You can give duplicate parts the high physical and chemical properties of stainless steel. And, you can do it without a heavy production penalty!

Simply set up and run Free-Machining ENDURO Stainless Steel Bars. They'll respond beautifully at every station on your automatics. Two grades are fully 90% as machinable as Bessemer screw stock.

These high-quality bars are cold-finished by Republic's Union Drawn Steel Division. They provide close tolerance, accuracy of section, uniform soundness, and fine surface finish.

Free-Machining ENDURO also is available in hot-rolled bars and in wire. Republic metallurgists and machining advisers are ready to help you apply ENDURO every step of the way. Just write:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • *Massillon, Ohio*
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N. Y.

NEW! **96-page pocket size booklet, "How To Machine Republic ENDURO Stainless Steel Bars." Packed with machining tips, tables of feeds and speeds, stainless steel properties, other vital information. Write Republic. Ask for ADV-607. FREE!**

REPUBLIC ENDURO FREE-MACHINING STAINLESS STEEL

REPUBLIC STEEL

Other Republic Products include Carbon and Stainless Steels—Sheets, Strip, Bars, Wire, Pig Iron, Steel and Plastic Pipe, Bolts and Nuts, Tubing

Use WELDED STEEL for Greater Strength with Less Weight!

The two Steel-Weld Fabricated propeller and engine mount sections for wind tunnels, illustrated above, and the parts and assemblies shown at the left, are typical of thousands of Steel-Weld Fabricated units produced and machined by Mahon for hundreds of manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. Perhaps you, too, should discuss this service with a Mahon engineer? If you require parts or assemblies including large, heavy pieces, where time and pattern costs are a consideration, Steel-Weld Fabrication may be the answer. You can turn to Mahon with confidence . . . personnel and facilities are available within the Mahon plant to do the complete job from drawing board to finished machining. You will find in the Mahon organization a unique source with complete ultramodern fabricating, machining and handling facilities to cope with any type of work regardless of size or weight . . . a source where skillful designing and advanced fabricating technique are supplemented by craftsmanship which assures a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication. See Mahon's Insert in Sweet's Product Design File, or have a Mahon engineer call and give you complete information.

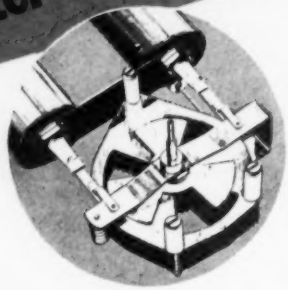
THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

An unbeatable pyrometer for any range between -300° and +2800°F.

DYNALOG* ... the electronic potentiometer that has no slidewire!



This simple variable capacitor is important to potentiometer users because it eliminates the conventional, troublesome slidewire altogether; and it gives Dynalog Instruments the continuous *stepless* balancing which assures higher accuracy, closer control.

TOPS in simplicity . . . unequalled in its combination of accuracy, sensitivity, and speed of response . . . the Dynalog Potentiometer with standard thermocouples gives you unerring temperature measurement for any range up to 2800°F. Featuring *sustained* accuracy of ¼ of 1% of scale, it's an instrument of laboratory precision built to withstand the severest industrial conditions.

Unprecedented freedom from maintenance is the direct result of unique Dynalog design. There's no slidewire, no battery to standardize. There are no gears, belts, or high speed reversing motors. There's nothing to wear and cause dead space.

Single pen recording models provide full scale pen travel in 3 seconds standard, or as fast as 1 second without extra cost. The Multi-Record Dynalog provides color-coded records of up to 6 points at 6 second intervals. Both types give the convenience and low cost of circular charts.

Dynalog Potentiometers are also used for the measurement of pH, oxidation-reduction potential, and for other applications in which the process variable can be converted to a dc millivolt signal. They are available for pneumatic or electric control.

Write for your copy of Bulletin 427-1 which gives the whole story.

*Reg. U.S. Pat. Off.

THE FOXBORO COMPANY, 526 NEPONSET AVE., FOXBORO, MASS., U.S.A.

FOXBORO REG. U.S. PAT. OFF. **POTENTIOMETERS**

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

Steel that puts on a coat to take a bath

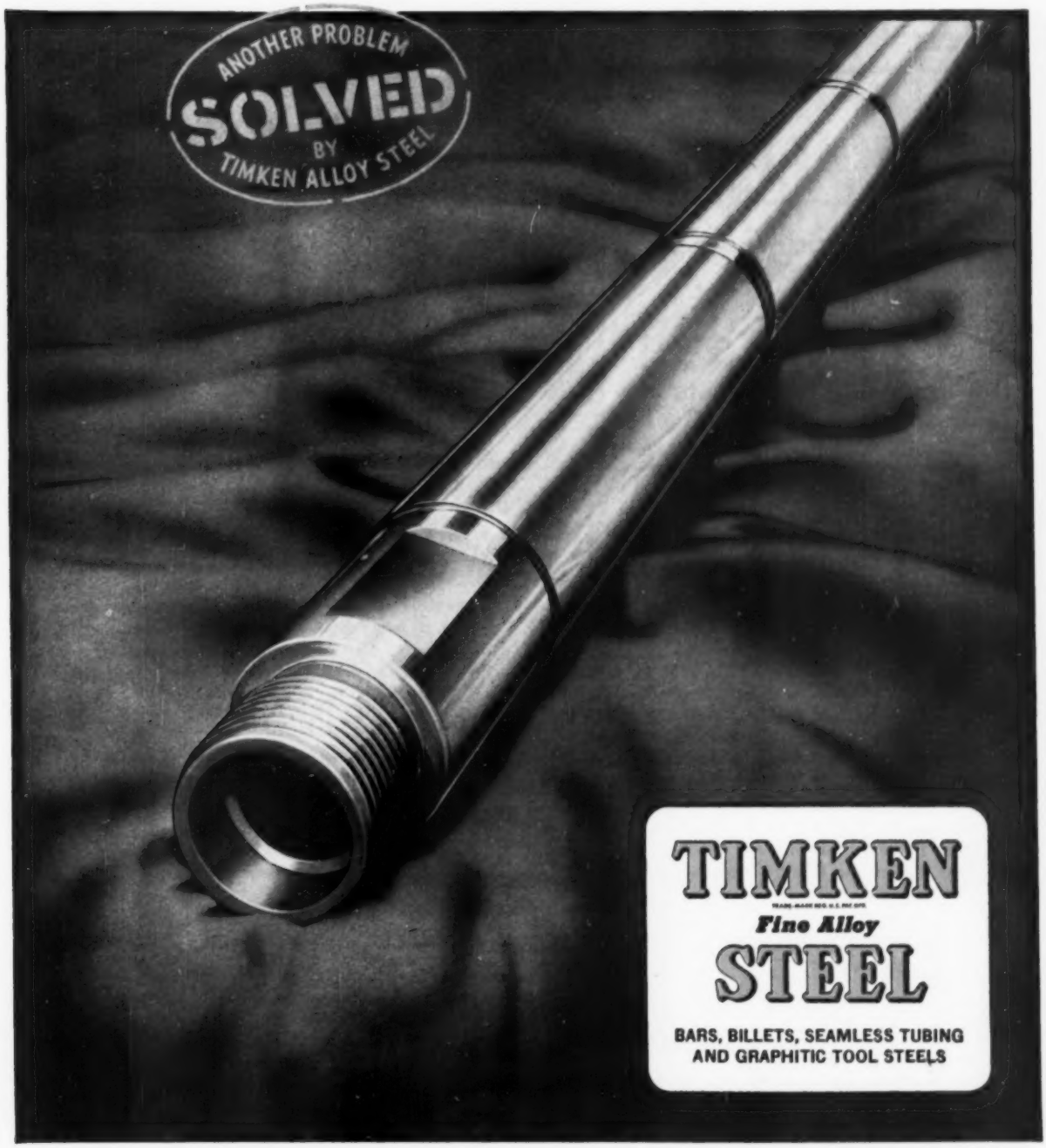
THE plunger in an oil well pump works thousands of feet underground where no one ever sees it. Yet it wears a costly coat of gleaming chrome-plate—vital protection against abrasive sand and grit and highly corrosive chemicals in the raw oil.

One manufacturer was having trouble getting the chrome to stay on. One out of every four plungers had to be rejected. The trouble was minute surface defects in the steel he was using.

Timken Company metallurgists were called in. They recommended a certain analysis of Timken seamless tubing that had the special qualities needed for this application.

The Timken steel proved to be the answer to this problem. It took the chrome-plating perfectly without a single rejection. Complete pumps rolled off the assembly line without costly production delays.

The files at the Timken Company contain records of hundreds of problems like this, solved by Timken alloy steel. Next time you have a tough steel problem, write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO". Tapered Roller Bearings, Alloy Steel and Seamless Tubing, Removable Rock Bits.



WANTED:

DRY air to protect valuable stock in storage at Kenilworth Steel

SUPPLIED:

By Lectrodryer . . . saves 2 steps in production and speeds shipments

PROBLEM: How may tempered spring steel—bright or colored—be stored in a 30,000 cu. ft. Kenilworth Steel storage area at Kenilworth, New Jersey so as to eliminate greasing and degreasing steps, yet provide maximum protection against corrosion?

SOLUTION: Installed CHR Lectrodryer* which maintains relative humidity of 30% or below. The moisture content of the air is reduced to a harmless level, below where rust could occur.

RESULT: Eliminates costly greasing and degreasing of tempered steel, feeler gauge and shim steel. Faster shipments are possible. Bright steel stays bright and free from corrosion.

What in the World do you want DRY?

There's a type of Lectrodryer to solve just about any moisture problem. Relative humidity control is possible to lower than 10%. Dewpoints may be preset to lower than –100°F. You can reduce the moisture content of air, other gases, and organic liquids, in large and small volumes, to pressures as high as 6,000 psi, with Lectrodryers.

Write for Because Moisture Isn't Pink

This booklet shows the actual use of all types of Lectrodryers, describing how Lectrodryers are the DRYing solution to industry's moisture problems.

Pittsburgh Lectrodryer Corporation, 317 32nd Street, Pittsburgh 30, Pennsylvania.

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

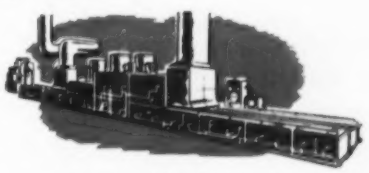
*REGISTERED TRADEMARK U.S. PAT. OFF.

BIG NEWS FOR BUYERS OF AIR CONDITIONING AND REFRIGERATION TUBING

After 4 years of designing, testing:

H&H announces a new Electric Annealing Furnace that features every modern technological advancement

Now you can look to H&H for an even finer tube, with an even brighter, more uniform finish that will last and last and last!



H & H TUBE AND MANUFACTURING COMPANY

Originators and sole makers of "Metalflo"—the economy tubing

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MICHIGAN, EASTERN
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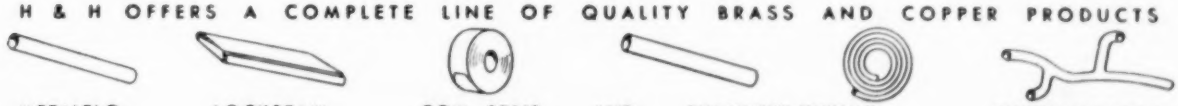
PACIFIC STATES
777 Stanford Ave., Los Angeles, Calif., Van Dyke 2082

To meet a steadily increasing demand by manufacturers of evaporators and condensing units, H & H is pleased to bring you an electric annealing furnace that ranks among the finest and most modern in the country. If maximum uniformity and permanence of finish are important to you, if you require tubing that is extra *bright*, extra *clean* and always absolutely *moisture free*—now, more than ever before, your best bet is H & H.

H & H OFFERS A COMPLETE LINE OF QUALITY BRASS AND COPPER PRODUCTS



METALFLO LOCKSEAM COIL STRIP AND SEAMLESS TUBING TUBULAR PARTS

NEW PROTECTIVE COATING CHEMICAL FOR ALUMINUM

ALODIZING

Alodizing with "Alodine,"* a new technique in the protective coating of aluminum, was made available for production-scale use in 1946. Since that time Alodizing has largely supplanted the more elaborate, costly and time-consuming anodic treatments in the aircraft and other industries.

Continuous and successful industrial use has clearly demonstrated the simplicity and economy of the Alodizing process as well as the effectiveness of the "Alodine" amorphous coatings, particularly as a base for paint. In fact, the paint-bond that Alodized aluminum provides has been found to be superior to that possible with chromic acid anodizing.

The corrosion-resistance of unpainted aluminum Alodized with "Alodine" Nos. 100 or 300 is excellent, easily meeting the requirements of Specification MIL-C-5541. However, a need for protection of unpainted aluminum, even better than that obtained with chromic acid anodizing, has long been recognized.

NEW IMPROVED "ALODINE" DEVELOPED By ACP RESEARCH CHEMISTS

Several years of intensive research have now led to a new type of "Alodine," designated as "Alodine" No. 1200. This new protective coating chemical forms an amorphous mixed metallic oxide coating of low dielectric resistance that provides unusually high corrosion-resistance for unpainted aluminum. In addition, it forms an excellent paint bond that approaches closely the high quality obtained with the earlier types of "Alodine."

After having been tested for conformance with Specification MIL-C-5541, "Alodine" No. 1200 is now about to go into production.

PROCESS DETAILS

"Alodine" No. 1200 is the only essential chemical needed to prepare the coating bath and the final rinse bath. One of its unique features is that it can be used in tanks in an immersion process, or, in a multi-stage power washer in a spray process, or, with a slight adjustment of pH, with brush or portable spray equipment in a manual process. This means that even where the simple production equipment is not available, or where touching up of damaged coatings previously Alodized or anodized is required, excellent protection and paint bonding can still be obtained with practically no equipment.

All three methods of application easily meet the requirements of Specification MIL-C-5541.

Process sequence for all three methods of application is the same as for other standard grades of "Alodine" such as Nos. 100, 300, and 600, viz.: 1. Pre-cleaning. 2. Rinsing. 3. Alodizing. 4. Rinsing. 5. Acidulated rinsing. 6. Drying.

Coating time in an immersion process ranges from 2 to 8 minutes and in a mechanized spray process is about 30 seconds. "Alodine" No. 1200 baths are operated at room temperatures (70° to 100°F.) and heating is required only if the bath has gotten cold after a "down" period.

RECOMMENDED USES FOR "ALODINE" No. 1200

"Alodine" No. 1200 is specifically recommended for coating wrought products that are not to be painted or are to be only partially painted; and for coating casting and forging alloys whether or not these are to be painted. "Alodine" Nos. 100 and 300 are still recommended for coating wrought products such as venetian blind slats, awnings, etc., that are invariably painted.

RESULTS OF TENSILE TESTS

This new "Alodine" not only retards visible corrosion and pitting, but as shown in the table below, the loss of ductility with "Alodine" No. 1200, both brush and dip after 1000 hours salt spray was less than for chromic acid anodizing after 250 hours; and for "Alodine" No. 100 and a conventional chromate treatment after 168 hours exposure.

PROCESS	SALT SPRAY EXPOSURE	COMPLIANCE WITH TENSILE REQUIREMENTS OF MIL-C-5541
CHROMIC ACID ANODIZING	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	fails
	1000 hrs.	fails
BRUSH "ALODINE"* No. 1200	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	passes
	1000 hrs.	passes
DIP "ALODINE" No. 1200	168 hrs.	passes
	250 hrs.	passes
	500 hrs.	passes
	1000 hrs.	passes
DIP "ALODINE" No. 100	168 hrs.	passes
	250 hrs.	fails
	500 hrs.	fails
	1000 hrs.	fails
CONVENTIONAL CHROMATE TREATMENT	168 hrs.	passes
	250 hrs.	fails
	500 hrs.	fails
	1000 hrs.	fails

*"Alodine" Trade Mark Reg. U. S. Pat. Off.

CHEMICALS ACP PROCESSES

AMERICAN CHEMICAL PAINT COMPANY

General Offices: Ambler, Penna.

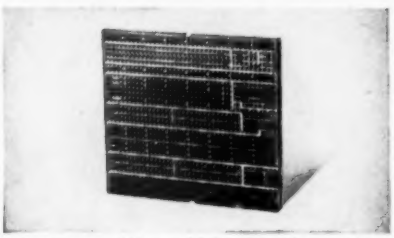
Detroit, Michigan **Niles, California** **Windsor, Ontario**

Make Sure You're Not Missing These Tooling Advantages!

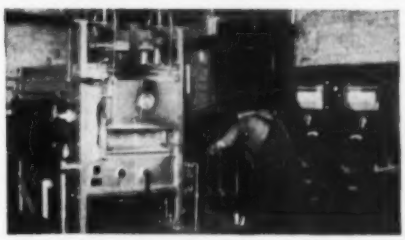
Make this *3-Minute Check* . . . Discover how a *modern* die steel can give you diemaking and production advantages no other steel offers you!

Are you aware of how tool and die steels have been improved in the last 5 to 10 years? New steels are now available that handle easier, run longer between grinds, bring down diemaking costs. Here are facts about *Vega* (Air-Tough) Die Steel—just one steel in Carpenter's Matched Set of 12 modern die steels. Compare *Vega* and what it offers, with the die steel you're using. Check it point by point. You'll see what a difference a Carpenter Matched Tool and Die Steel can mean to *your* production and profits. THE CARPENTER STEEL CO., 133 W. Bern St., Reading, Pa.

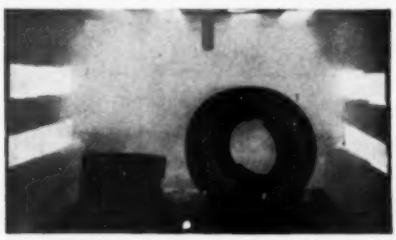
Here is what *Vega* gives you . . . *COMPARE* it with the die steel *you* use . . .



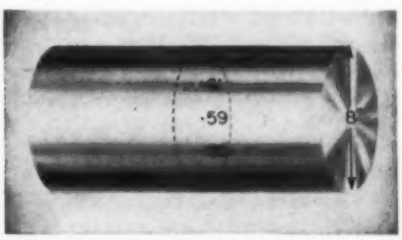
Freedom from Size Change in Hardening. The mold for this 9½" x 10½" plastic control panel has 1,280 5/32" dia. holes, six ⅜" dia. horizontal ports for heating and cooling, plus eight ¾" dia. tapered holes on the edge. *Vega* was the *only* steel of many tried that could successfully hold the close tolerances of .0002" on centers of the 1,280 holes! Will the steel you use behave in hardening like this?



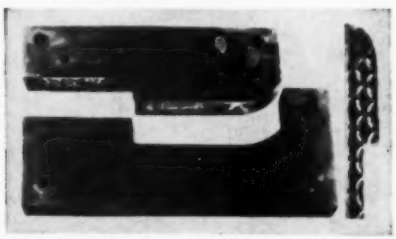
Easy, Low Temperature Heat Treating. You heat treat *Vega* from a temperature of only 1550°F (actually 200°F *lower* than the 5% chromium air-hardening grades!). No need for special, high temperature furnaces! Are you getting the benefits of *low temperature* heat treating from the air-hardening steel you use?



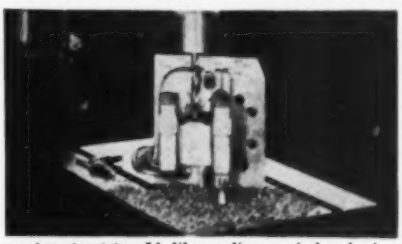
Extra Economy in Hardening. Because of *Vega's* lower hardening temperature, troublesome pack hardening to avoid excessive scaling is usually unnecessary. Does the air-hardening steel you use give you this *extra economy* in hardening?



Uniform Deep Hardenability. *Vega* gives you the advantages of uniform, deep hardenability in very heavy sections. For example, *Vega* hardens to Rockwell C-60 from surface to center in sections as large as 8" round. How does the steel you use compare on this score?



Toughness with Good Hardness. This punch and die blanks ¼" diamond threshold plates at one stroke. With previous air-hardening die steel, tools chipped and broke before any real production was made. With *Vega* these tools are in regular production—and there are no signs of wear or chipping to date. Will the steel you use perform in service like this?



Good Machinability. Unlike ordinary air-hardening grades, *Vega* has a well balanced analysis with a small percentage of hard-to-machine alloys. Field tests prove it to be one of the easiest of all air-hardening grades to machine. If the air-hardening grade you use fails to provide this *good machinability*, you're missing out on lower costs.

change to *Carpenter* STEEL — **Matched Tool and Die Steels**

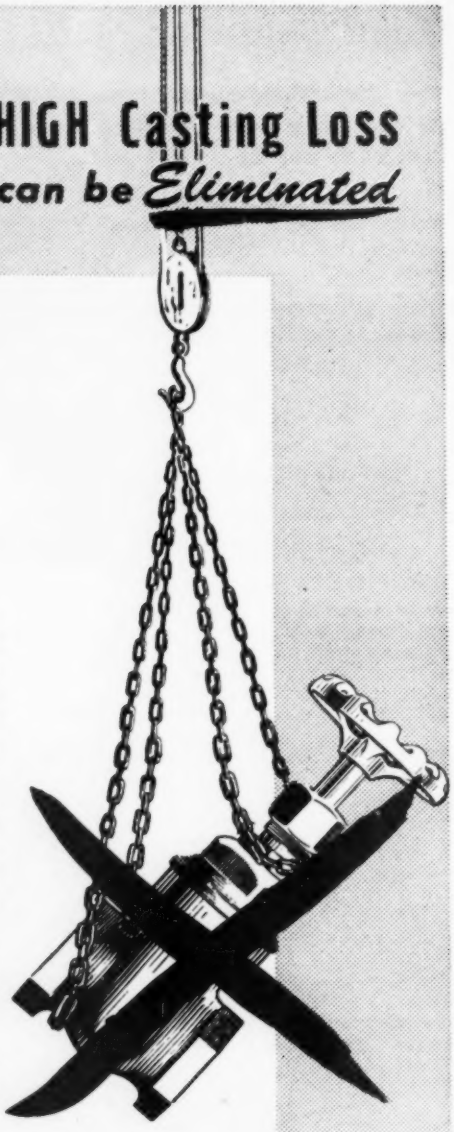
. . . *modern* die steels engineered to meet *today's* requirements!

Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Get Immediate Delivery . . . Call your Carpenter Mill-Branch Warehouse, Office or Distributor.

THERE IS A SOLUTION
TO YOUR NONFERROUS
Foundry Problems...

HIGH Casting Loss
can be Eliminated



When you call upon
LAVIN'S ENGINEERING SERVICE

The following are some of the causes of LOSING CASTINGS: 1. Permeability of molding sand is too low. 2. Strength of Molding Sand is too low. 3. Molding sand is too wet. 4. Gas holes from a core buckle. 5. Gas holes around cores. 6. Overheating and soaking metal. 7. A porous horizontal line which leaks. 8. Dirty ladles. 9. Dross inclusions embedded in side walls. 10. Cooling casting too rapidly. 11. Metal was poured too hot. 12. Using the swab too freely. 13. Improper furnace combustion. 14. Soft mold ramming. 15. Improper core making. 16. Steam holes from paste in cores. 17. Proper gate but riser ill-proportioned. 18. Undried ladles. 19. Holes from parting and mold cracks. 20. Watch your charcoal. 21. Improper gate. 22. Poor core mixtures. 23. No choke in sprue or runner. 24. Cold Metal.

While we have listed the most common causes for losing castings, the making of each particular casting must be considered as an individual problem.

Lavin's metallurgical staff is always ready to assist the foundryman in finding the solution of any routine or special casting problem. Our chemical and research laboratories are available to you at no cost or obligation.

Next time call upon LAVIN'S engineering service
"The Foundryman's Problems Are Our Problems"

FREE: Write for your copy of the 20-page Lavingot technical Journal Vol. 10. No. 1 & 2 Containing, Specifications . . . test bar designs Nonferrous Ingot & Casting Alloys in chart form.

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• REFINERS OF BRASS, BRONZE AND ALUMINUM • PRODUCERS OF ZINC BASE DIE CASTING ALLOYS • DEOXIDIZERS . . . DEGASIFIERS . . . FLUXES . . . SHOTS • CAST VIRGIN ELECTROLYTIC COPPER ANODES • TYPE METALS.

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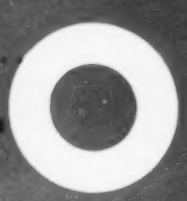
R. LAVIN & SONS, INC. 1900 *54 Years* 1954 SERVING THE FOUNDRY INDUSTRY

Cents per lb. for Bearing Bronzes Isn't the Whole Story...

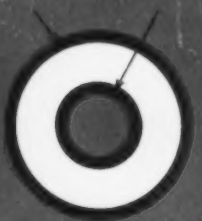
IF YOU BUY A ROUGH-CAST BAR . . .

to make this 

1" I.D. x 2" O.D.
Weight: 9.0 lbs./ft.

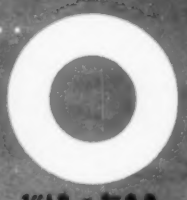
you get this

¾" I.D. x 2¼" O.D.
Weight: 13.5 lbs./ft.

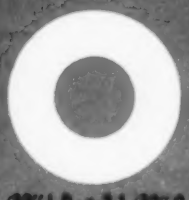
note the scrap loss 

4.5 lbs./ft. lost!

BUT IF YOU BUY ASARCON 773 . . .

to make this 

1" I.D. x 2" O.D.
Weight: 9.0 lbs./ft.

you get this 

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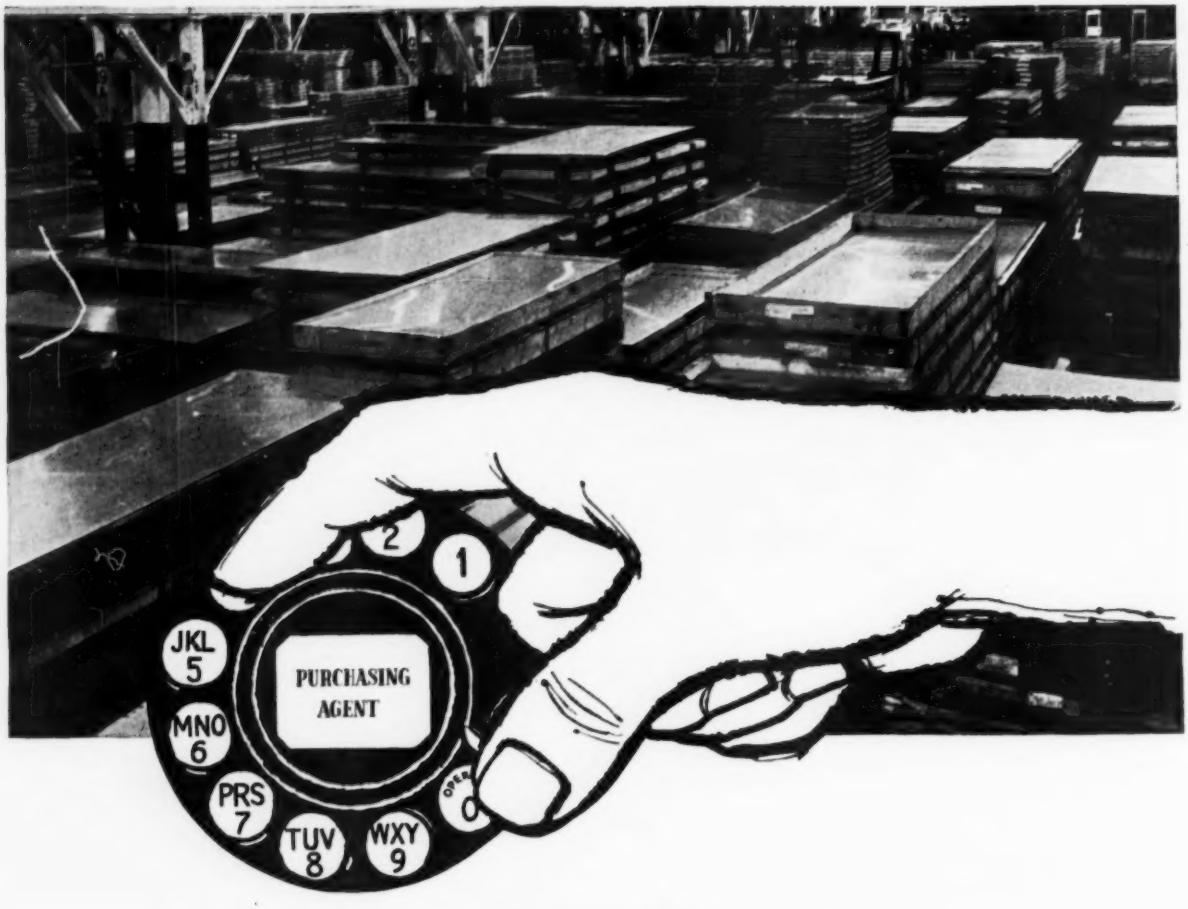

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The New Radiometallurgy Laboratory at the Hanford Atomic Operation

By THOMAS W. GORE, Engineer, Technical Section
Hanford Atomic Products Operation, General Electric Co., Richland, Wash.

ONE OF THE newest buildings at the Hanford plutonium manufacturing plant, operated by General Electric Co. for the U.S. Atomic Energy Commission at Hanford in southeastern Washington, is the radiometallurgy laboratory. This building is part of a new "Works Laboratory Area" in which a large amount of research and development work is performed in the radiometallurgy field. A prime activity is the examination of the physical characteristics and mechanical properties of irradiated materials, particularly the uranium fuel slugs from the Hanford piles, directed toward the long-sought solution to many problems in the behavior of fuel elements under irradiation. Other programs at the Laboratory involve the mechanical testing of irradiated materials.

Because irradiated materials mean radioactivity, those in charge of the design and construction of the building had to take into account not only the various levels of radioactivity which would be encountered from the microcurie (small or cool) to the multicurie (large or very hot) scale, but also any hazards arising from direct radiation from a source, or indirect acquired radiation from the building or equipment, or from introduction of radioactive materials into the body.

In order to plan such a building, knowledge of the mean free path of alpha, beta, and gamma particles of varying energies through different mediums (air, concrete, steel, lead, water) was of primary importance. Design and location of such areas as entrance and service corridors, lunchrooms, washrooms, counting rooms, offices, cell blocks, hot and cold storage areas, equipment rooms – to mention only a few – required such data. Location and shielding required for contaminated drains and air exhausts also had to be carefully studied so contaminated wastes could be disposed of with safety.

So, one of the first considerations in planning the radiometallurgy building was to estimate the general level of radioactivity which would be encountered in the various intended operations. The general building plan was then prepared and modified in the light of such problems as adaptability, safety (especially from a radiation standpoint), and ability to fit

into long-range planning. The final arrangement was then chosen on the basis of suitability in operation, cost of construction, and economy of maintenance.

General Plan – The building is one story (with basement under certain portions) and is constructed of reinforced concrete and steel. Floor space is more than 14,000 sq. ft. This space is divided into "cold" areas (entry hall, lunchroom, and part of the locker room) and "regulated" areas (the rest of the building). "Hot" areas are those in which radioactive materials are stored or handled and thus require shielding of personnel or equipment. Conversely, "cold" areas are free from radioactive materials. A "regulated" area is one which has some likelihood of contamination, even though it is an area without radioactive materials. (The use of "hot" or "cold" in this sense does not indicate thermal differences.)

Experience at Hanford with scientific and engineering work in the presence of radiation is that the flow of traffic should be coordinated so the cold and hot areas are segregated insofar as possible. Personnel movements should be controlled to minimize traffic in the potentially hot areas, to reduce the possibility of tracking any contamination into other locations. In conformity with this principle, the main entrance and rooms for cold operations are located in one end of the building and the hottest areas are in the remote end. As shown in the floor plan, Fig. 1, interlocked doors of an airlock separate cold from controlled areas. The lunchroom and the cold half of the locker room are the only parts of the building to which access is permitted in street clothing.

The locker room is divided into a cold portion and a regulated portion. Changes from street clothing to work clothing, which usually includes coveralls or lab coats, canvas shoe covers, hats and gloves, are made in this room. There are separate lockers for street clothing and for work clothing. Toilet and wash facilities combine convenience with the best of sanitary protection. Wash basins are foot-controlled so those who work with hot materials need not touch the basin with their hands.

After the architect-engineers had considered the layout and arrangement of facilities to provide maximum utilization, convenience, and safety, they turned to the needs of the research men. Building materials must resist chemical activity, be capable of shielding personnel or instruments from radioactive particles, and, above all, they must be readily decontaminated or cheaply replaced.

Adaptation to future needs is, as previously stated, of utmost importance in a laboratory of this type. It is far more essential than in normal industry. This is easily gained by movable metal partitions with baked-on enamel finish. (Several manufacturers have successfully produced partitions which can be readily cleansed of acquired radioactivity.) However, the major problem has been to reduce the size of the cracks separating the panels. Some successful solutions involve either sealing the crack with special tape or filling it with metal putty (similar to that used in the auto industry) and then spraying it with a special enamel. Metal partitions have been produced with a blue-gray baked enamel which have successfully passed rigid tests for humidity resistance, accelerated weathering, washability, nonpolishing, alkali resistance, and acid resistance.

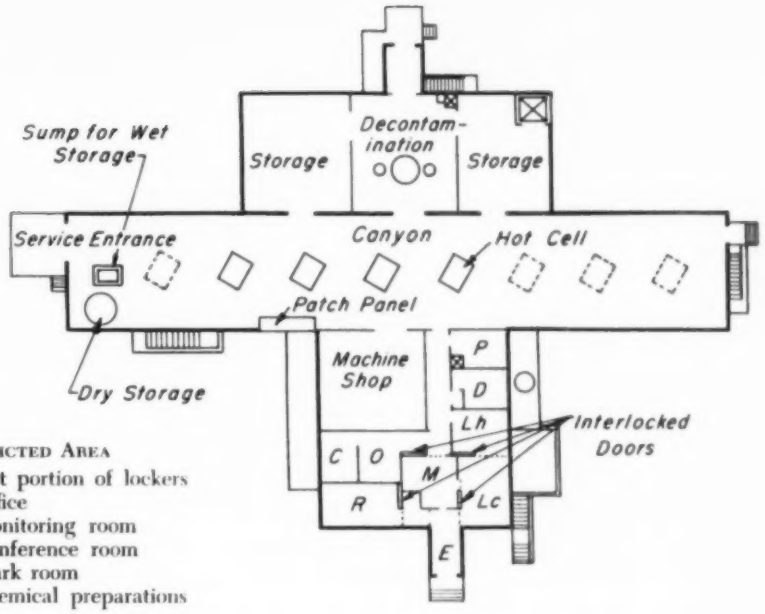
Hung ceilings, preferably formed with metal pans, are very suitable in combination with movable partitions. Electrical and other services can be initially installed above them, and frequent painting or maintenance is not required. Fluorescent lighting (which places the lighting tubes within the ceilings) is easily maintained and economical.

Decontamination – Floor covering can be asphalt, rubber, or vinyl tile. Large, continuous sheets are preferred by many, since the number of cracks through which contamination from a spill may enter are reduced. Although sheet vinyl can be patched if necessary, smaller squares are more easily replaced. It is sometimes desirable to paint exposed concrete in those areas where heavy equipment and service dictate a finish which is resistant to abrasion as well as to chemical attack. "Amercoat 33" was used in the "canyon" area of this laboratory; the manufacturer's instructions for installation and service were carefully followed. This finish is not a cure-all but does give satisfactory service if properly applied.

Laboratory furniture is of commercial metal design wherever possible. Standard units were purchased and metal fillers fitted the units into odd-shaped rooms. In this way combinations can always be interchanged.

Many materials are available for bench tops. Among these are formica, chemstone, soapstone, transite and others by various trade names. For our radiometallurgy laboratory a bench top made of 1.25-in. transite with a baked-on semigloss insolite enamel was selected. A suitable cove molding was placed at bench-

Fig. 1 – Main Foor Plan. Entrance to the building is through the electrically interlocked doors of the locker room. For reasons of safety and security, the doors are remotely controlled from the building supervisor's office so that persons must first identify themselves over the intercommunication system before they are admitted. There also is a service entrance at the end of the "canyon", opened only after calling the office on the intercommunication system. Several emergency exits are provided, but for safety and security the doors can be opened only from the inside.



OPEN AREA
E – Entrance hall
R – Lunchroom
Lc – Cold portion of lockers

CONTAMINATED AREA
Canyon section

RESTRICTED AREA
Lh – Hot portion of lockers
O – Office
M – Monitoring room
C – Conference room
D – Dark room
P – Chemical preparations

top height along the wall (where liquid spills may work behind furniture and possibly damage or contaminate the wall and equipment). Also a drip groove to catch spillage before it runs down the face of metal furniture is located underneath the bench top.

Fume hoods (Fig. 2 and 3) are of standard designs so that they can be placed on the standard furniture units. Stainless steel is the favored material for hoods. However, it does have some disadvantages which could outweigh its advantages in some industrial applications. For example, it will inevitably corrode if hydrochloric acid is used. A more economical hood for such applications might be of transite with a removable vinyl or plastic liner. Coatings which can be stripped and discarded are exceedingly economical in radioactive work.

The many variations in hood design underlie most of the difficulties in designing the heating and ventilation system. It is imperative that the air velocity at the hood face be controlled, within reasonable limits, at either constant volume or a variable volume. Air movement must be sufficient to eliminate back drafts into the laboratory and the escape of any air once it enters the hood. It is desirable to minimize the face velocity since this also reduces the size of exhaust ducts and fans. Most laboratory experiments cannot withstand face velocities in excess of 200 ft. per min., although a carefully designed hood can permit a velocity as low as 50 ft. per min. This range gives the planner a choice of many types of hoods, depending on cost, nature of the controls, and the air system.

Ventilating – There are many arrangements which can be utilized, and the selection will be affected, obviously, by many considerations other than mechanical. The fundamental layout of the building, as a whole, precedes the arrangement and design of the heating and ventilation system.

When the building consists of several laboratory rooms, a modular design is the most feasible (using the word "modular" in its architectural sense of "unitary"). This means that each room has essentially the same air-handling system. This arrangement can, and of course should be, expanded to include all laboratory services. Each room then has all the needed facilities supplied on a completely repetitive basis. The air supply, like other services, is common in all locations and the modular system would allow the required number of hoods to be placed within each room to satisfy the intended functions.

The flow of air in radiation laboratories should move air from the cold areas to areas of higher contamination risk. From both an economic and health standpoint a strict airflow pattern is necessary, just as it is necessary to establish a traffic-flow pattern. Fresh air intakes into the building are normally located by the architectural features; however, they are always at the remote point – considering prevailing winds, location of exhaust and other sources of possible air contamination.

The simplest control may be essentially only a start-and-stop operation, with interlocks to shut off the supply when the hot exhaust is

closed. This prevents contamination from spreading throughout the building, and is the minimum essential for health and safety.

There are many ways of exhausting air from a laboratory to the atmosphere, but experience has shown that a single stack is superior to multiple exhaust, since a more rigid control can be maintained over air flows, the facilities can accommodate new arrangements, and maintenance is reduced. When a stack is necessary, a ventilating system possessing "hot" and "cold" exhaust fans dispersing into a single exhaust plenum is highly desirable. The height of the stack and material of construction depend on the level of radioactivity and type of fumes that will be exhausted.

Figure 4 shows exhaust air filters in the basement of the Hanford laboratory. The choice of air filters is largely determined by the dust to be collected and the degree of cleanliness desired in the exhaust. Air coming from laboratory hoods may be saturated with water, or have a high concentration of acid mist; these two possibilities alone influence the choice of the filter. Disposable-type hood filters located downstream from hot exhaust fans protect the ducts from excessive comtamination and corrosion, warrant less expensive duct work (for example, aluminum instead of stainless steel) and greatly reduce the amount of contamination to be dissipated on the outside.

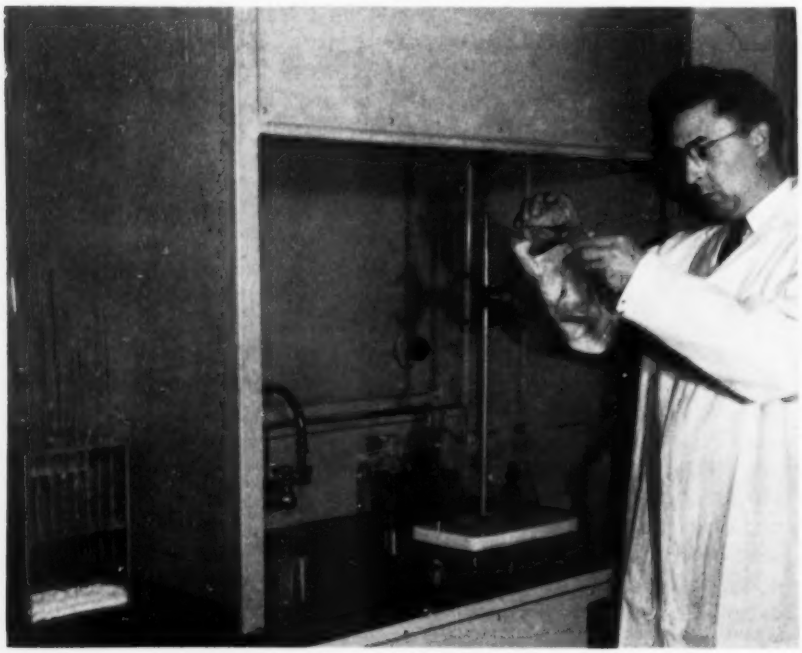
Establishment and maintenance of the airflow pattern is of the greatest importance. A system of installed air locks is of questionable practicability since it is difficult to make a building air-tight, the differentials of pressure maintained between different areas are relatively low, and the system is complicated as well as costly.

Necessary controls involve, essentially, means of maintaining the required differential of static pressure between the various areas within the building. These controls are rather complicated and are beyond the scope of this article.

Supply and exhaust ducts in radioactive laboratories are usually galvanized iron. Stainless steels are preferred when handling high levels of activity. Depending on the dilution factor, other materials may be coated black iron, "lucoflex", aluminum and some others offering resistance to corrosion from the various vapors to be anticipated. The selection of material deserves careful consideration from the standpoint of present and future use, initial investment, and maintenance costs.

Radiation Instruments – All the laboratories handling radioactive material must establish monitoring requirements. For low-level laboratories, portable instruments are satisfactory, such as alpha hand counters, beta-gamma hand and foot counters, general background counting meters, and other portable hand instruments. In addition, film badges, rings, and similar monitoring devices should be worn by laboratory personnel.

Fig. 2 – Fume Hood in Chemical Preparation Room Is a Transite Up-Draft Hood With a Sprayed-On, Acid Resistant Lacquer. Economical and utilitarian for chemical preparation and low-level radiation work



Hot Cells – Storage, handling and study of metals having a high degree of radioactivity in the Hanford Metallurgical Laboratory are confined to a room called the "canyon". As shown in the plan and Fig. 5, it is a long, high-ceilinged room commanded by a traveling crane. It contains four cells with foundations for four more.

Fig. 3 – Down-Draft Hood for Low Contamination Areas. There are many considerations underlying the basic design of a down-draft hood. A contaminated exhaust hood of this type must have filters located beneath the laboratory floor in order to eliminate costly shielding at ceiling level. This hood has a stainless steel tray and substructure, and an "Amercoated" superstructure

radioactive specimens, either dry or in liquid form, that have previously been placed in ordinary tin cans. The cell is similar to a soft drink vending machine, with five perforated steel disks, one above another, rotating about a central shaft. Each disk can be rotated so that the holes line up to permit individual samples to be inserted or removed. Approximately 7½ ft. in diameter and 6½ ft. deep, the cylindrical unit will hold more than 700 samples.

Contaminated Waste Disposal – A major question remaining to be answered by the designer of a building such as the radiometallurgy laboratory is how best to get rid of radioactive waste. Half of the problem can be solved by realizing that radioactivity is to be respected but not feared; by

Fig. 4 – Exhaust Air Filters. The air exhausted from all cells, hoods, and other equipment which may contain radioactive materials is ventilated by a down-draft exhaust system and passes through "C.W.S. Type 6" filter elements located immediately beneath each cell. When contaminated, these filters have to be removed in a shielded device. The operator is shown pulling a filter into a specially designed dolly; note that he at no time handles the filter and is able to place the dolly in variable positions

Construction of these cells is shown in Fig. 6 and more fully described in the caption. A remote-controlled metallograph is mounted on one of these in Fig. 7. The patch panel indicated in the plan contains all necessary terminals so that 120 and 240-volt alternating current, 24 and 120-volt direct current, 480 - volt three phase can be supplied to any cell at will. Thermocouple circuits and indicating and recording devices are also mounted on this panel.

Recessed in the west end of the canyon deck is a unique dry storage cell, designed and built for Hanford, for storing small

close cooperation with the scientist, a reasonable and economic solution can be attained. The scientist is concerned primarily with the selection of the waste-disposal method, while the designer must provide the necessary facilities or structure. For simplicity, two policies of waste disposal may be compared: (*a*) Concentrate and contain the activity, ultimately disposing of it by burial in land or sea, or (*b*) dilute the radioactivity in water or disperse it in the atmosphere.

Handling of liquid waste was segregated into three systems at the Hanford Laboratory, namely, (*a*) liquid-disposal lines for normal washrooms and sanitary facilities, (*b*) drains for normal neutralized or chemical waste, known as process waste, which is no more of a problem than in normal laboratories, and (*c*) hot liquid waste lines which require special materials of construction and some means of ultimate disposal which may depend on the site and the facilities already existing. The last mentioned waste may be collected in suitable containers, after passing through stainless steel lines or traps, and sent to a central location for processing. Properly designed evaporators have proven satisfactory for the job of concentration. Other means of disposal are the ion exchange method and the practice of mixing the waste with concrete in standard drums. Finally the block of concrete is dropped into the sea or buried in some controlled area.

Experience has proven that small laboratories that are not compelled to dilute their waste should use the "concentrate and contain" policy.

Combustible and noncombustible varieties of solid waste demand different methods of disposal. Moreover, these methods are dependent upon the amount of radioactivity present. Burning will ordinarily dispose of combustible ma-

Fig. 5 – View of Canyon Area Showing Multicurie Cells, Patch Panel (Right) and Foundation for Additional Cell (Lower Right Foreground). Four cells are shown in which irradiated samples with high or intermediate level of radioactivity are studied. Within the cells, metallurgical samples can be prepared, examined, photographed and tested, using a variety of specialized equipment. Three of the cells have walls 10½ in. thick, and one 15 in. thick; internal dimensions are the same in all. They are duplicates in all respects except that one has more shielding against greater radiation

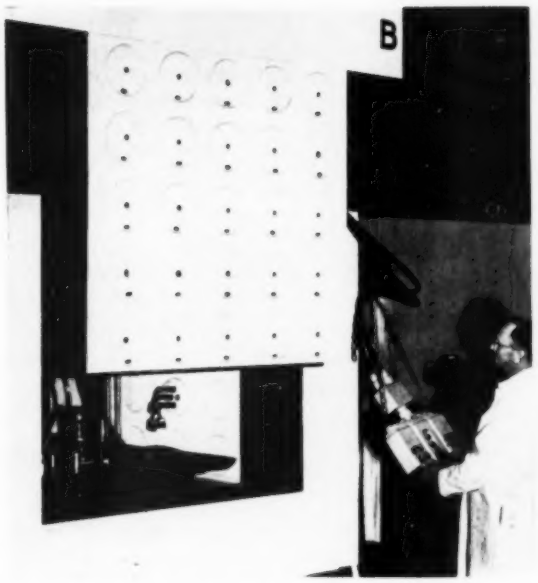


Fig. 6 – High Level Cell. The operator is removing the door; it is cast Meehanite, 15 in. thick. Essentially the cell is a cast Meehanite enclosure set upon steel pedestals (see Fig. 5). The base contains the service panels and associated equipment. Each cell has plug openings from four sides and top; plugs are machined to fit the ports in each cell. Any service required within the cells can be provided through them, such as lighting, electric service, air and gas, thermocouple, sample entry, manipulator, and viewing plugs. (Note electric service plug shown within the cell.) Cells can easily be disassembled; top plates and doors are stepped and dovetailed into the side section to give a rigid structure, as well as complete protection against radiation and contamination

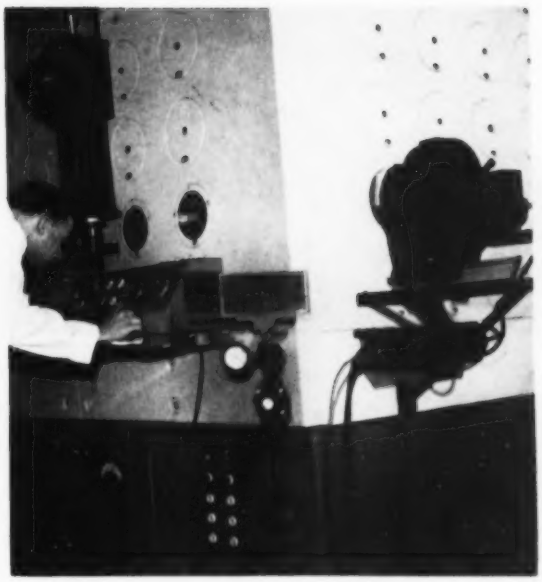


Fig. 7 – Remote-Controlled Metallograph Designed and Fabricated by Erb and Gray Co. for Operation Within a 10½-in. Cast Meehanite Cell. The essential motions required to investigate the microstructure of radioactive metals behind a shielded barrier are accomplished by mechanical and electrical linkages extending through plugs in the cell wall. Lead glass viewer plugs are shown in their position for direct observation. An air sampling device for health monitoring is shown at the corner

terials; no special treatment is required unless activity is concentrated in the ash. A great amount of solid waste at Hanford is of the noncombustible type, and the only possible course is to bury it.

SUMMARY

To summarize some of the major considerations in the design of a hot laboratory which differ from normal architectural practices and which should be carefully borne in mind:

1. The importance of planning circulation and traffic control as a part of radiation monitoring. Radiation must be reduced to within tolerance levels for personnel. Contamination must be confined to specific localized areas. A good layout will help to restrain the spread of contamination by good housekeeping practice.

2. Radioactive laboratories should have more floor space for workers than conventional laboratories. Large storage areas for contaminated equipment and for process equipment must be provided.

3. Modular concepts of laboratory services and facilities should receive special study. The interior layout should be sufficiently adaptable so future adjustments can be easily and economically made. Modular design will expedite design and construction, and will improve the flexibility of occupancy.

4. Ventilation systems for radioactive work are very different from those in the usual laboratory. The general movement of air should be from levels of lower activity to levels of higher activity. The nature of the materials to be handled in the laboratories is of primary importance, as it seriously affects the selection of the type of exhaust system.

5. Suitable waste disposal system. Small laboratories should adapt the "concentrate and contain" philosophy.

Many current standards in nuclear engineering were unheard of ten years ago—the progressive metallurgist should not fail to look ahead now.

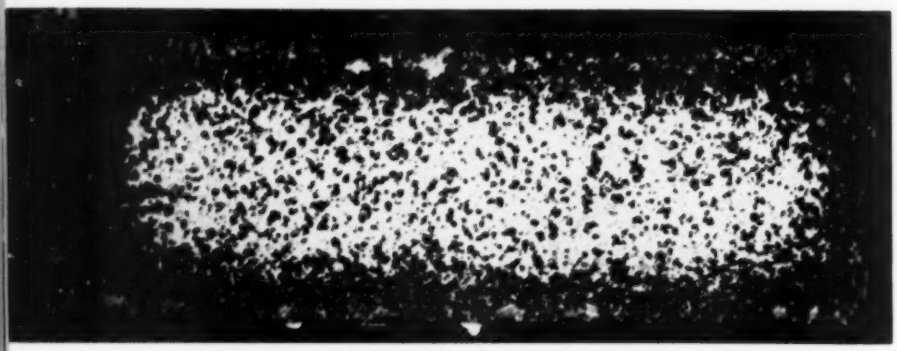


Fig. 1 – Partially Deboronized Specimen Showing Predominantly Martensitic Center and Pearlitic Surface Region. Austenitized 30 min. at 1600° F. in commercial argon and quenched slightly slower than the critical cooling rate. 40×

Deboronization of Steels

By J. C. SHYNE and E. R. MORGAN, Metallurgical Department
Scientific Laboratory, Ford Motor Co., Dearborn, Mich.

BORON as an additive to alloy steels for the purpose of increasing hardenability is unique in several respects. Added in minute quantities, it can cause a remarkable increase in hardenability as compared to similar amounts of other alloying elements. The small amounts required per ton of steel and the abundance of boron make it an almost unlimited resource as a hardenability agent for low-alloy steels.

Unfortunately, the use of boron in steel is accompanied by several difficulties. Some of the anomalous behavior which has been attributed to boron steels may have been caused by deboronization. Boron, like carbon, is removed from steel at austenitizing temperatures by a process of oxidation at exposed surfaces combined with diffusion to those surfaces. Boron differs from carbon in that the oxide of boron is solid and remains on the surface while carbon has gaseous oxides. While this fact has been known for several years,* the practical implications of deboronization in connection with the standard end quench hardenability test have so far been ignored.

Deboronization first appeared to the authors as an experimental difficulty while heat treating some small specimens of an iron-carbon-boron alloy. These experimental steel specimens had been austenitized in an argon atmosphere and cooled to room temperature at controlled rates. The loss in boron was indicated by nonuniform microstructures in specimens cooled at rates near the critical cooling rate of the alloy. Figure 1 shows a cross section of one such nonuniform specimen. The sample was small enough (0.100 x 0.100 x 0.040 in.) so that it was cooled at an effectively uniform rate throughout. Pearlite formed at the surface regions while the center was predominantly martensitic. That the hardenability of the surface regions had been decreased by deboronization was established by spectrographic analysis of microdrillings taken from regions near the center and surfaces of such specimens. (See "A Method of Metallurgical Microspectroscopy", by F. R. Bryan and C. H. Neveu, *Metal Progress*, Vol. 64, December, 1953, p. 82.) It is interesting to note that the oxygen content of the argon atmosphere was sufficient to cause deboronization, and yet failed to produce decarburization.

Subsequent work showed that it is extremely difficult to prevent deboronization by any

Due to loss of boron from surface layers of steel during austenitizing, the authors believe that Jominy hardenability of a boron-treated steel may be reported considerably too low unless the hardness surveys are made on flats ground deeper than the standard 0.015 in.

*See "Effect of Boron on the Hardenability of High-Purity Alloys and Commercial Steels", by T. G. Digges, C. R. Irish, and N. L. Carwile, *Journal of Research of the National Bureau of Standards*, Vol. 41, 1948, p. 545.

means. Specimens of boron steel were plated with copper, nickel, chromium and other metals. None of these prevented boron removal in a commercial argon atmosphere during austenitizing. Either the plated layers were permeable to oxygen, or boron was able to diffuse out through the plated layer. Attempts to prevent deboronization by removal of oxygen from commercial argon were unsuccessful. Commercial argon was purified by passing it over heated titanium chips; the oxygen content was reduced from the original 0.0240% to 0.0014% (mass spectrograph analysis). No detectable decrease in the deboronizing tendency of the atmosphere resulted.

As a consequence, some experiments were made to determine the effect of deboronization on the end quench hardenability test. Most of the published experimental work performed with boron steels has involved the use of the end quench test. Also, boron steels are bought and sold on hardenability band specifications. Therefore, if deboronization can affect end quench hardenability data, boron steels may have been improperly evaluated in many instances.

It was believed that the extent of deboronization could be limited by drastically reducing the oxygen content of the furnace atmosphere by suitable vacuum or getter techniques. Portions of a split heat of S.A.E. 4118 and S.A.E. 41B18 steels were obtained and machined to standard 1-in. round end quench bars. These were copper plated to prevent any change in carbon content during austenitizing. Previous experience indicated that copper plating should have a negligible effect on deboronization. The bars were then austenitized under three sets of conditions, namely, in vacuum (10^{-5} mm. Hg), buried in charcoal, and buried in ferroboron. In each test the austenitizing temperature was 1750° F. and the total time in the furnace was 80 min. After the standard end quench had been performed, flats were ground on the surfaces of the bars. Instead of the usual pair of flats 180° apart and 0.015 in. deep, several pairs of flats were ground. These were at different depths – 0.005, 0.015 and 0.040 in. On every bar the two flats of equal depth were 180° apart. Hardness surveys were made in the usual way using a Rockwell C penetrator. Hardness values from each pair of flats were recorded as the average for each distance from the quenched end.

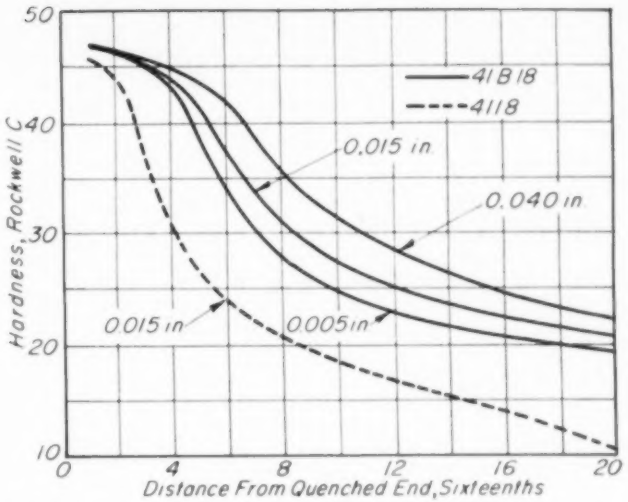
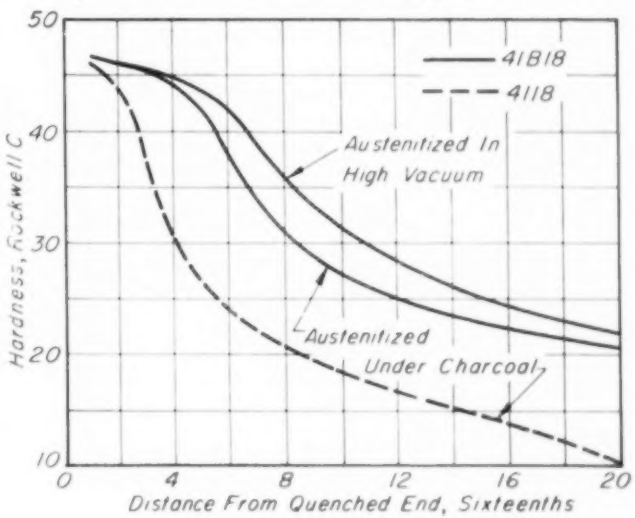


Fig. 2 – End Quench Hardenability Curves for a Split Heat of S.A.E. 4118 and 41B18 at Various Depths Below the Surface. Copper-plated end quench bars austenitized at 1750° F. under charcoal for 80 min.

Hardenability curves are plotted in Fig. 2 and 3. The boron steel specimen austenitized 80 min. at 1750° F. under charcoal was deboronized to such an extent that the hardenability was significantly different at different levels below the surface of the specimen (Fig. 2). The boron-free S.A.E. 4118 steel, austenitized and examined in an identical manner, exhibited the same hardenability curve at all levels. Especially important is the fact that the boron steel data taken from the standard depth of 0.015 in. do

Fig. 3 – Hardenability Curves at the Standard Depth (0.015 In.) for a Split Heat of S.A.E. 4118 and 41B18 Steels Austenitized at 1750° F. for 80 Min. in the Indicated Atmospheres



not indicate the true hardenability.

The boron steel bar austenitized in high vacuum (Fig. 3) did not show decreasing hardenability near the surface as did the one heated under charcoal. The vacuum-treated specimen had a uniformly high hardenability at all levels. In fact, all the hardenability curves of the vacuum-treated boron steel bar were practically identical with the curve from the deepest level (0.040 in.) of the specimen heated under charcoal. Apparently no deboronization occurred during the high-vacuum heat treatment.

The boron steel austenitized in ferroboron (not shown in the curves) did not exhibit different hardenability at different levels, but the hardenability was uniformly low at all depths below the surface. This was caused by a heavy coating of ferroboron particles which adhered to the surface of the bar, affecting the heat transfer characteristics of the quenched end.

Although at no depth did the boron steel specimens show as low hardenability as that of the steel without boron, it is obvious that the usual end quench test did not give a true measure of the hardenability of this boron steel.

Values for the diffusion coefficient of boron in austenite have been reported by P. E. Busby, M. E. Varga and C. Wells in "Diffusion and Solubility of Boron in Iron and Steel", *Journal of Metals*, Vol. 5, November 1953, p. 1463. Knowing the diffusivity of boron, it is possible to compute the degree of deboronization which has occurred in an end quench bar after various times and temperatures of austenitizing in a deboronizing atmosphere.* Figure 4 is a plot of such computed values for a position 0.015 in. below the surface of a 1-in. diameter end quench bar. The curves show the percentage of the original amount of effective boron remaining as a function of time at temperature. The computed values assume that all boron is in solution; they apply only when the solubility limit of boron in austenite is not exceeded at the austenitizing temperatures. This is a good assumption for most boron steels. It should also be pointed out that the curves apply only to effective boron which is in solution and not to boron which is permanently tied up as B_2O_3 or possibly as other stable compounds, such as BN.

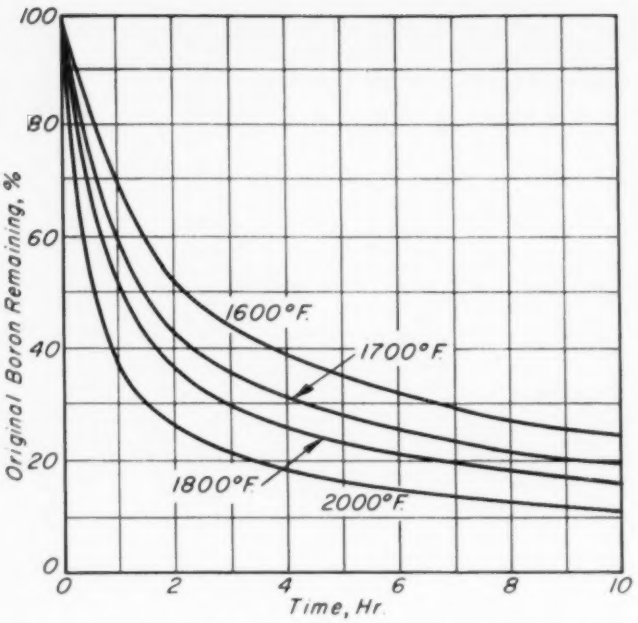


Fig. 4 — Computed Deboronization Curves for a Position 0.015 In. Beneath the Surface of a Standard End Quench Bar

CONCLUSIONS

The experimental results described above and the computed deboronization curves suggest that the standard end quench procedure ought to be modified for boron steels. The problem of deboronization during the austenitizing of end quench specimens can be avoided simply by making the hardness survey on flats prepared at sufficient depths below the surface.

In view of the demonstrated deboronization effects, much of the published data on boron steels must be regarded in a new light. The possibility that deboronization may have occurred during end quench tests cannot be ignored. Experiments which have involved long times or high temperatures should be especially prone to this type of error. Similarly, results of such experiments as those in which end quench bars are carburized are subject to deboronization errors because deboronization seems to occur even in a carburizing atmosphere. It is proposed that a modification of the standard end quench test procedure be adopted for boron steels in order to eliminate possible errors resulting from deboronization.

*The solution of this type of problem is discussed by Carslaw and Jaeger on p. 272 of "Conduction of Heat in Solids", Oxford University Press, London, 1950.

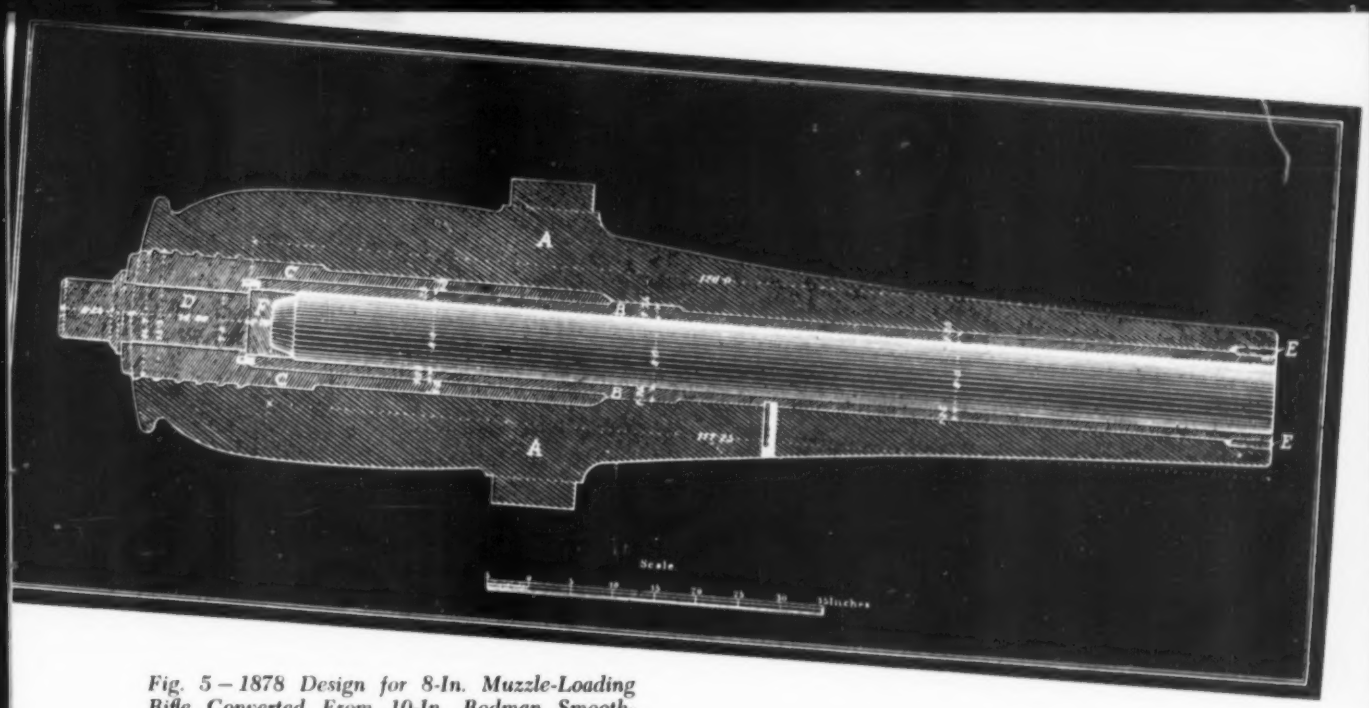


Fig. 5 – 1878 Design for 8-In. Muzzle-Loading Rifle Converted From 10-In. Rodman Smooth-Bore Cast Iron Gun by Lining With a Coiled and Welded Wrought Iron Tube, Breech Inserted. (From Annual Report, Chief of Ordnance, 1880)

A – Cast iron casing
B – Coiled and welded wrought iron tube
C – Coiled and welded wrought iron jacket
D – Cast iron breech plug
E – Collar at muzzle end
F – Wrought iron cup

Materials for Large Army Gun Tubes
A History—Part II
Wrought Iron and Brass Cannon

EXPERIMENTATION by the Ordnance Corps with wrought iron for large cannon has been relatively limited. In 1832, two small wrought iron guns were tested. In comparison with bronze guns, one was more resistant to "balloting" (damage by indentation from rebounding of the shot as it passes along the bore) but was eroded more. In the other, the welded joints opened up at time of proof and the gun was condemned.

In 1843-1844, an investigation was undertaken by Franklin Institute and Watertown Arsenal on a 12-in. naval gun of American manufacture, which had failed by bursting unexpectedly. The gun had been made by welding together 30 bars of wrought iron 4 in. square and 8½ ft. long. The bars were laid

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together in the usual manner of a faggot and were forged into a solid cylinder about 21 in. in diameter. No welding flux was used. Three encircling segments were welded onto the outside of the cylinder to build up the thickness. A second layer was then welded on to further build up the breech end. It took 45 days to finish the gun, which was kept hot all of this time. The average time to bring the breech end up to welding heat was 4 hr. The hammer used for welding weighed 15,000 lb. The weight of the gun before being bored was 27,390 lb. The weapon had been satisfactorily proofed "in the coldest weather of the past winter".

To determine the quality and strength of the metal two fractures were made in the same bar, one by a slow tensile pull, the other by nicking and breaking in an anvil. The former fracture was fibrous and the latter was crystalline, and was taken as evidence of inferior metal.

Tensile tests were made of metal taken from the gun and also from bars representing the iron used. Samples were also subjected to the welding procedure. Tensile strength of samples taken from the gun ranged from 25,800 to 41,400 psi., averaging about 33,600. Three samples taken from the gun and welded showed tensile strengths of 52,500, 58,000 and 69,000 psi. Comparable iron taken from bar stock ranged from 45,000 to 50,000 psi. before welding, and tests taken after welding gave values of 39,000 and 49,000 psi. It was concluded that the metal used in the gun was of inferior quality and was imperfectly welded.

In 1845 a new method of building up cannon out of wrought iron was tried. Rings were welded together on a mandrel using a hydraulic press. Weapons in 6, 9 and 12-pounder sizes were satisfactorily proof-fired. Other methods of making wrought iron field guns were later developed.

The next experiments of importance on wrought iron cannon were carried out in compliance with an order of President Abraham Lincoln in 1864. A rifled gun weighing 19,400 lb., 7-in. caliber and about 168 in. long was built up around a long handling bar starting from the cascabel. The end of the bar was enlarged by welding pieces around it and then successively welding on two rings concentrically to give an outside diameter of 28 in. Against this end piece was welded a three-piece disk 4 in. thick and 28 in. in diameter. It consisted of a 10-in. diameter centerpiece surrounded by two concentric rings, all machined and fitted together. Next to this was welded a three-piece compound annular disk, 4 in. inside diameter, 28 in. outside diameter and 5 in. thick. Other such compound rings were welded on, one after the other, until the required length was obtained. A horizontal steam hammer was used for welding the disks and a vertical hammer was used against the sides of the piece.

The inner ring of each compound disk was made from a block of iron 10 x 10 x 6 in. by boring a 4-in. hole through it and turning the outside. The fiber was normal to the axis of the gun. The other rings were made by bending bar stock and welding the ends together. Here the fiber was circumferential. These rings were then machined to size and fitted together to make the compound disk. The inside ring was slightly longer than the others to make sure that when the disks were welded together a perfect joint was obtained next to the bore.

After firing 19 rounds, a circumferential crack was observed in the bore near the breech end. As firing continued, numerous holes and cavities appeared and the crack was enlarged. After 700 rounds, the crack was 1⅜ in. deep and was considered to have penetrated the full thickness of the inner ring. The gun did not break up, and the process was approved for the manufacture of large cannon.

In 1866, five similar weapons were submitted for proof firing. One was withdrawn because of the existence of bore defects, another failed on the first round, and another broke after firing nine rounds. One withstood 220 rounds under conditions more severe than any known gun in service. However, bore defects were sufficient to condemn the gun, and it was concluded that such guns were not suitable for service.

In 1872, still another unique procedure was recommended for making wrought iron guns. Seamless rings were to be welded together under a vertical steam hammer. The furnace was situated between the hammer and the anvil; it had a hole in the roof for the hammer, and a hole in the hearth for the anvil. The anvil, immediately under the furnace, was seated on the piston of a hydraulic press. The piston was lowered as the successive rings were added. One ring at a time was heated for welding, so that metal was at high heat for a minimum length of time. The gun was to be built up starting from the muzzle end; however, after nearly three years' effort, this experiment was stopped, the procedure being considered impractical. No gun was successfully made by this technique.

Liners for Cast Iron Guns

In Part I of this history (May *Metal Progress*, p. 90) reference was made to the lining of smooth-bore cast iron guns with wrought iron tubes. Following a recommendation made in 1867, arrangements were completed in 1874 for a program involving several cast iron guns lined with steel and wrought iron. Two muzzle-loading guns, one 8-in. and one 9-in. were made with muzzle-inserted wrought iron liner. Experimental guns with steel liners will be described in a later installment.

The wrought iron liners were obtained from England. The 8-in. gun, which was made from a 10-in. Rodman cast iron gun, was at once established as a success. The 9-in. gun also performed satisfactorily when fired, but was considered to be too light for the purpose intended. A third gun was successfully made, using a wrought iron liner manufactured in America. The conversion of a large number of guns was then undertaken. In the last ones, the bar iron used was wholly American-made.

The operation required the handling of wrought iron bars 36 ft. and more in length. A coal-fired furnace 75 ft. long was used for heating these bars.

Puddle-bars were first formed into blooms about 18 x 4 x 4 in. in size. These were rolled into muck-bars 2 to 4 in. by ⅝ in. in cross section. These were repeatedly piled and rolled. The final pile was about 9½ x 7 in. in cross section when ready for final rolling. The bars which were sent to the gun maker were in 16 and 18-ft. lengths. The cross section was an irregular hexagon, 4 in. on the longest edge and perhaps 1½ in. on the shortest edge. This cross section was especially designed to suit the welding operation. Composition and tensile properties were:

Carbon	0.016%	Copper	0.01%
Manganese	0.02	Nickel	0.02
Silicon	0.16	Cobalt	0.05
Sulphur	0.003	Cinder	0.01
Phosphorus	0.20	Iron	99.5

Elastic limit	22,500 psi.
Tensile strength	52,000 psi.
Elongation	30%
Specific Gravity	7.66

Pairs of bars were welded together, forming lengths of about 36 ft. These were then heated and coiled over a mandrel. The distance between coils ranged from ⅜ to 1½ in.

These coils were then welded together to form sections of the liner. Two cast iron "welding pots" were used, slightly conical on the inside. The inside diameter of one was about 1 in. larger than the finish diameter of the tube; the inside diameter of the other was ⅜ in. larger.

The coiled bar was heated to redness, placed inside the first pot and pressed under an 8-ton steam hammer, to close the coils. It was then heated to welding temperature, placed in the same pot and hammered until too cold for further welding to take place. The coil was then reheated, placed in the second pot and the operation of hammering repeated until it was shortened to the correct length for the liner section. The dimensions of the bar after the coils were closed were about 4½ ft. long and, roughly, 13 in. in outside diameter. After welding, the liner section was about 3 ft. long, 5 to 7 in. ID and about 14½ in. OD.

The next step was machining. A projection was machined at one end and a recess was machined on the mating end of the adjacent section, such that a shrink fit was obtained. The recessed section was expanded by heating and fitted to the mating unit. The two sections were then placed in a special furnace so that only the joint was heated intensely. The sections were butt welded under a powerful screw press while still in the furnace. The joint was upset by this operation so the liner was taken to the steam hammer and reshaped. Four such sections were welded together to form the liner. After machining, the liner was subjected to a hydraulic pressure test at 120 psi.

The breech end of the liner was closed by means of a breech cup which was threaded and screwed into place.

When this method was tried with guns of larger diameter (10 and 12¾ in.), the customary defects were encountered, some welded joints being imperfect. Failure occurred as a result of the longitudinal stresses encountered in firing. This experience led to the use of the breech-inserted liner. In this mode of construction, as shown in Fig. 5, several shoulders were located along the outside of the liner and corresponding steps were machined inside the cast iron casing to give better support to the wrought iron liner in the longitudinal or axial direction. Experimental guns were proved for endurance and several 8-in. and 11-in. guns were converted for service. However, the development of breech loaders limited the number of 11-in. guns which were converted.

Eventually, the technique of inserting liners in 8-in. guns from the muzzle was changed in favor of breech insertion. In 1883 steel was substituted for wrought iron, as will be described in a subsequent installment.

Bronze Gun Tubes

Cannon made of bronze are commonly called "brass cannon". The composition initially specified ranged from 9 to 11% tin, remainder copper. This alloy is often referred to as "gun bronze". It originated in antiquity and was used in this country from the very beginning, the adoption probably being based upon French practice.

In the early 1830's, the reliability of brass guns was evidently questioned. In 1839, the Ordnance Corps reported to the Secretary of War that, after two years' effort, "It may therefore be assumed that we can hereafter manufacture brass guns to any extent that may be required."

Initially, bronze guns were cast in loam or sand molds. A wooden pattern of the gun was made, with allowance of at least 1 in. over the finished diameter, both for shrinkage of the casting and for machining. The gun was usually cast breech-end down. The sinkhead extended from the muzzle, and was about equal in diameter to the casting at the muzzle; the volume of the sinkhead was about one-third the volume of the whole casting.

For the smaller guns, a single two-piece flask was used. It was hexagonal in shape and divided longitudinally; each half had strong flanges and was strengthened by ribs. Each side adjoining the flanges was solid but the third side in the half-flask was loose. This side was removed while preparing the mold. Well-tempered sand moistened with water and clay or with clay and beer lees was rammed uniformly around the pattern. After the pattern was removed, the mold was dried in an oven, and the surface was coated with a wash of graphite, fine clay, molasses and water and dried again. Sometimes the mold wash consisted of a mixture of charcoal, clay and water.

The molds were stood upright in especially prepared pits. In the early period, it was usual to heap sand up around the molds to a height corresponding to the location of the trunions.

The molds were usually bottom-fed; if top-fed, a runner box was used. The metal took a long time to solidify. When casting 24-pounders, the sand heaped up around the outside of the flask was not removed for three days.

Later (probably in the 1870's) chill molds were used. The walls of the chill were 2½ to 3½ in. thick; inside surfaces were covered with a wash of fine clay, molasses and water and heated moderately in an oven. Bottom feeding became more prevalent than top feeding.

All brass cannon were bored 0.04 to 0.05 in. undersize for proof-firing. This was done so that damage from dents made by the cannon balls during proofing could be corrected. After proof-firing, the bore was cleaned and examined for cracks and other defects. For such inspection the gun was filled with water for 24 hr. (alternatively, pressure could be applied to the water). The bore was then sponge-dried and inspected to determine if any water oozed out from cracks or cavities. If the quantity of water exceeded a few drops, the gun was judged rejectable; if acceptable, the bore was then reamed out to proper size and again examined for defects. Extensive white spots showing segregation of tin were another cause for rejection.

The specific gravity of the weapons was also occasionally determined. For this purpose the inspecting officer carried with him a sensitive scale suitable for weighing bronze guns in air and in water.

In 1848, it was observed that the density of a 32-pounder was low. The density of some 6, 12 and 42-pounders was found to range from 8.38 to 8.68. The same investigation showed that the density of metal in the same gun ranged from 8.33 to 8.78 and the tensile strength ranged from 22,200 to 46,600 psi. The density of satisfactory gun bronze was considered to be 8.700.

In 1850, close supervision by Ordnance officers of the manufacture of brass cannon (similar to that in existence for cast iron cannon) was instituted.

Large numbers of brass cannon were made during the Civil War. Modifications were made in the chemical composition, and a 90-10 Cu-Sn gun bronze and 88-10-2 Cu-Sn-Zn gun metal were used for 12-pounders in 1863 and 1864. Three typical compositions and corresponding tensile properties are given in Table V.

More than 100 24-pounders cast in 1863-64 for the Navy Department were tested, and had an average

Table V – Chemical Composition and Mechanical Properties of Bronze Cannon*

Composition				Tensile Strength, Psi.	Elastic Limit, Psi.	Elongation	Reduction in Area	Specific Gravity
Cu	Sn	Zn	Fe					
90.6	9.4	tr	—	45,400	14,000	36%	32.3%	8.7
88.7	9.5	1.8	tr	40,600	14,000	28.1	24.5	8.8
90.8	7.7	1.5	—	39,100	12,500	32	31.3	8.8

*Tests made in 1902 on metal taken from 12-pounders cast in 1863-64.

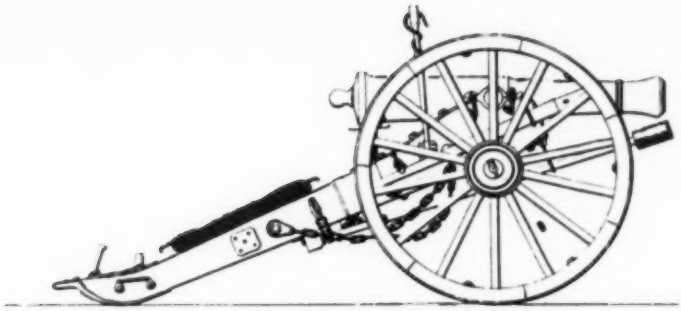

Fig. 6 – Brass Field Gun and Carriage, Circa 1850. (From "Ordnance Manual", published by Gideon & Co., 1850)

density of 8.722 and average tensile strength of 50,000 psi. Nine weapons in this group had an average density of 8.804 and tensile strength of 60,600 psi. In another group, the average density was 8.65 and tensile strength, 33,700 psi.

In 1876, 3.5-in. caliber muzzle-loading rifles were being chill-cast. The metal in the furnace charge weighed 3584 lb., the casting 3126 lb., the riser 700 lb., and the finished gun 1322 lb. Density ranged from 8.57 to 8.67 and tensile strength from 37,700 to 48,200 psi.

Experiments were made with this gun to determine the influence of cold working the metal at the bore surface. The gun was bored to a diameter of 3.37 in. Six mandrels varying in diameter from 3.42 to 3.50 in. were successively forced down the bore and withdrawn. A hydraulic press with a 10-in. piston operating at pressures up to 2500 psi. was used for this operation. The tensile strength of metal near the bore was 35,800 psi. before and 51,600 psi. after cold working. The gun was fired and performed satisfactorily enough but the ballistic characteristics were poor.

New designs of heavy weapons were under consideration in the period 1872 to 1888, and the use of steel-lined and steel-jacketed bronze barrels was suggested. But the Ordnance Corps had many objections to bronze. It was relatively costly; it was too soft and easily dented by the ammunition. When the gun was fired rapidly and the barrel got hot, the muzzle end drooped. All in all, bronze was not considered suitable for large guns.

Statements and opinions in this article are to be understood as individual expressions of the author and not those of the Ordnance Corps, Department of the Army.

Carbon Restoration of Bar Stock With a Batch-Type Furnace

IT IS VIRTUALLY axiomatic that the marketability of an item or commodity is enhanced when the manufacturer offers the customer a better product – both parties benefit from this improvement. An improvement of this kind was achieved recently with the production of cold finished bars in which surface carbon was restored. Previously this stock required costly operations to remove the decarburized surface before further processing could proceed. Now, the bars from the cold finishing mills that require heat treatment are processed in a radiant tube, carbottom-type furnace specially built (by the Surface Combustion Corp.) for use with carbon restoration atmospheres, Fig. 1.

Rounds, hexagons, flats, and squares are treated either as straights or coils. The size of the straights is from ½ to 12 in. diameter and

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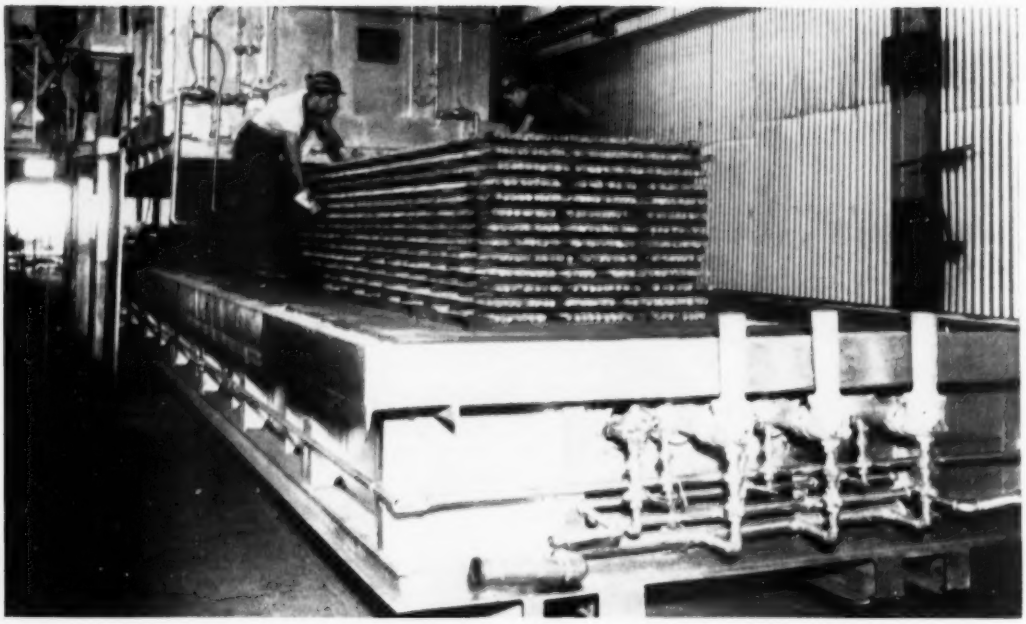
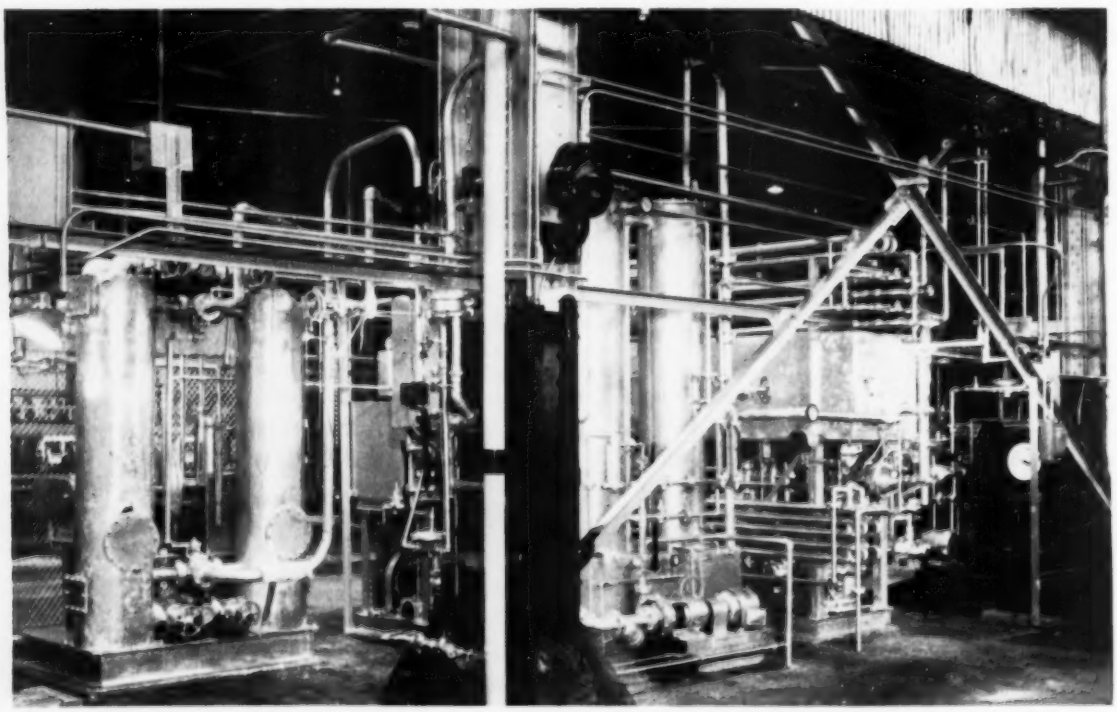


Fig. 1 – Operators Adjusting Spacers in Load of Hot Rolled Bar Stock for Carbon Restoration. Note radiant tube burners and flexible gas and air connections in end of car. Three tubes are also located in opposite end of car

Fig. 2 – Prepared Atmosphere Generators Located Immediately Adjacent to the Furnace. NX generator and coolers are in foreground, RX generator and dew-point recorder in background

that of the coiled stock is up to ⅝ in. diameter. The coils are up to 40 in. diameter. This stock is either in a pickled and limed, or cold drawn condition before being treated. The decarburized zone is from 0.005 to 0.032 in. deep. Diverse steels are treated, ranging from the low carbons such as C-1008, C-1015, and C-1020



to the high-carbon grade C-1095, and the various alloy types.

Although this variety of stock sizes, shapes, grades, types, and surface conditions is treated in a single furnace, a rigidly uniform high quality is maintained from piece to piece and charge to charge.

CONTROLLED-ATMOSPHERE BATCH PROCESSING

Not only annealing with carbon restoration, but also bright annealing, conventional annealing, spheroidizing, normalizing, and stress-relieving are carried out in the carbottom furnace as dictated by variable mill production and customer requirements.

The basic principles and theory of reactions encountered in controlled atmospheres during heat treatment, both reactive (gas carburizing, carbon restoration) and protective (bright annealing), will not be described as they have been dealt with in detail in several published reports embracing extensive research and successful application.*

Atmosphere Generators

Two generators (Surface Combustion Corp. make) furnish the protective (NX, exothermic) and reactive (RX, endothermic) controlled atmosphere required for all processing. Both units, shown in Fig. 2, are adjacent to the furnace and are manifolded to the lift cover.

The NX generator, of 2500 cu. ft. per hr. capacity, produces the atmosphere used in the heating up and cooling periods during carbon restoration, and also for bright annealing. Composition of this atmosphere is < 0.1% CO_2, < 2.0% CO, < 2.0% H_2, 96% N_2.

The RX generator, 2400 cu.ft. per hr. capacity, produces the reactive atmosphere for use during the active period of carbon restoration.

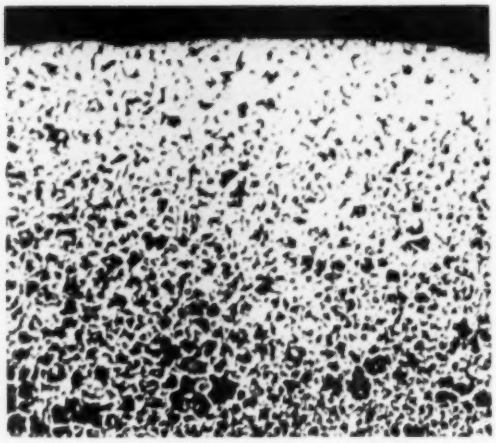
*"Advantages and Applications of Carbon Restoration", by O. E. Cullen, *Steel*, Vol. 121, Nov. 19, 1947, p. 94.

"Carbon Concentration Control", by E. G. de Coriolis, O. E. Cullen and Jack Huebler, *Transactions*, Vol. 38, 1947, p. 659.

"Dewpoint Vs. Pct. CO_2 as Furnace Atmosphere Control Check", by W. T. Groves, *Industrial Heating*, Vol. 16, June 1949, p. 966.

Heat Treatment Processes in Batch-Type Furnace

	Carbon Restoration — Annealing	Annealing (Before Cold Drawing)
Purpose	Restoration of carbon to the decarburized surface of hot rolled bar stock.	To decrease the hardness of hot rolled bars before cold drawing.
Sizes	21/32 in. diameter and over.	All sizes and shapes of bars.
Grades	A.I.S.I. C-1035 to C-1050, C-1050 to C-1144.	C-1040 to C-1095, and high-carbon resulphurized grades.
Charge	15 to 30 tons per load.	20 to 40 tons per load.
Loading	"Layer" loading.	Bundled loads.
Cycle	Heat to 1200° F. in NX atmosphere, then add natural gas. At 1400° F. switch to RX atmosphere enriched with natural gas. Soak 6 hr. at 1650° F.; reduce volume of natural gas during soak. Force-cool charge in furnace and switch to NX at 1400° F. Uncover load at 1100° F.	Heat to 1200° F. in NX atmosphere. Add natural gas. Soaking period, temperature, and cooling rate determined by grade and application.
Results	Complete correction of decarburized zone. Usual carbon limit is 0.10 to 0.15% above ladle carbon.	A decrease in hardness of 60 to 110 Brinell.
	Bright Annealing	**Normalizing**
Purpose	Relieve cold working stresses without loss of dimensional accuracy and finish of cold drawn stock.	To relieve stresses developed in rolling or forging.
Sizes	All sizes and shapes.	1 5/32 in. diameter and larger.
Grades	Most free-machining grades.	Intermediate carbon and low-alloy.
Charge	20 to 40 tons per load.	15 to 30 tons per load.
Loading	Bundled loads.	Layer loading of hot rolled or forged stock.
Cycle	Soaking period, temperature, and cooling rate determined by grade and application. Cool in furnace to below oxidizing temperature. Uncover load at approximately 200° F.	Soak 4 to 8 hr. (dependent on stock size) in NX atmosphere at 50° F. above upper critical, air cool.
Results	Complete elimination of cold work hardness while retaining cold drawn finish and size.	Uniformity of structure and physical properties.



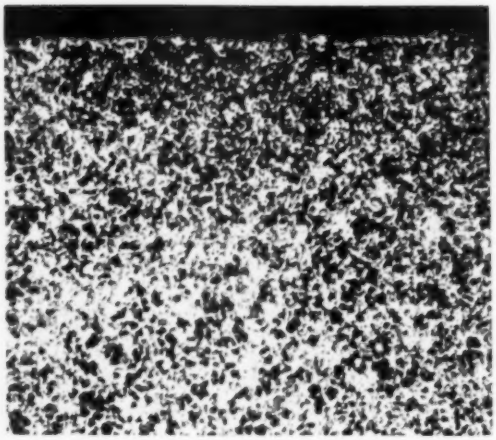


Fig. 3 – Typical Before and After Micrographs for Carbon-Restoration Annealing of 1 13/16-In. Diameter C-1045 Steel. Carbon analyses were: ladle 0.48%; ring test (0.015 in.) 0.28% for as-rolled and 0.59% for carbon-restored material. Etched in 4% nital, 75×

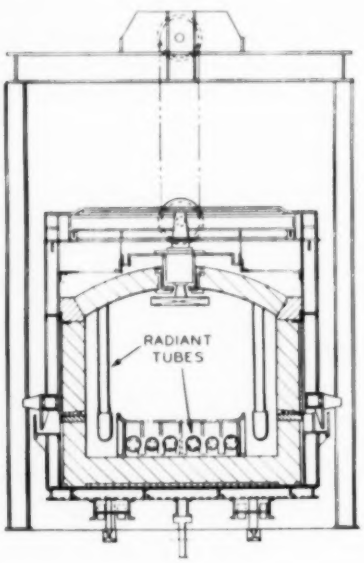
Its analysis is essentially 0.4% CH_4, 20.0% CO, 40.0% H_2, and 39.6% N_2. Determinations of carburizing potential are made with an automatic dew-point recorder made by Surface Combustion Corp. Annealing up to 1200° F. is carried out in straight NX gas, but above this temperature a fixed amount of enriching natural gas is added to prevent decarburization. The enriching gas is always turned off for a period of time before the furnace cover is raised.

The principal heat treatments carried out in this controlled-atmosphere batch furnace can be adequately described by summarizing each process as in the tabulation on p. 97.

Although continuous furnaces are ideal for large productions where relatively constant material and process requirements exist, batch-type furnaces offer the most practicable means for heat treating a large volume of work of job-lot variety that involves different requirements. The furnace installed in the Jones & Laughlin cold finishing department is 43 ft. long and 6½ ft. wide internally and has 52 radiant tubes in the lift cover and 6 in each of the two cars. Each radiant tube is equipped with an individual burner and exhaust eductor. A slight negative pressure is maintained in each tube to prevent the products of combustion from contacting the work while it is being heated. If a leak should develop in a radiant tube, furnace atmosphere is drawn into the tube and out the eductor so as to keep the products of combustion from entering the heating chamber where they could contaminate the furnace atmosphere. Maximum furnace heat input is approximately 5 to 6 million Btu. per hr. using natural gas at line pressure. These tubular heating elements are also used to cool the furnace during accelerated cooling cycles.

The roof arch of the furnace cover has eight recirculating fans to equalize temperature and distribute atmosphere gases uniformly throughout each charge. The self-contained lift cover is served by two cars that are coupled together and can be moved in either direction from under the cover by a car puller. In practice, the load on one car is under cover while the load on the other is being air cooled to handling temperature. Limit switches prevent movement of the cars until the cover has been raised to a safe position.

Operating Procedure – Work is loaded directly on hearth piers and is evenly spaced along the length of each 40-ft. car.



Charges for the carbon-restoration anneal are tiered, as shown in Fig. 1, to permit maximum circulation of the atmosphere gases and heat throughout the charge. For some of the other processes the work is handled in bundled loads. The maximum weight per charge is about 85,000 lb. of bars, although this heavy loading, on a round-the-clock basis, results in a high production rate from this single furnace when the two carbottom hearths are used interchangeably.

The bars are stacked on 1¼-in. spacer bars usually to a height of about 38 in. Four thermocouples are used at different levels along the length of the furnace charge to check work temperature. Temperature variation is less than 20° F. at the end of the soaking period.

There are five zones of temperature control, three in the furnace cover and two in each of the cars. Each zone has two thermocouples, one to control work temperature and the other to control the temperature of the radiant tube. Overheating of the radiant tube is prevented by two interrupters, one for the three zones in the cover and the other for the two zones in the car. All regulating and recording instruments are located on a central panel.

After the five work zones reach the desired temperature, a timer holds the control temperature for a predetermined period in all parts of the furnace. The subsequent cooling rates are set according to metallurgical requirements; either slow or fast for the initial cooling, and either slow or fast for the final cooling. These rates are regulated by two time-delay devices.

Furnace for Carbon Restoration

During the cooling cycles the radiant tubes in the furnace cover automatically heat or cool the charge to maintain the desired temperature gradient.

Operating Safety – On account of the highly combustible gas mixture required for controlled atmosphere processing, adequate safeguards are necessary to protect the equipment and personnel. In addition to the standard gas and air pressure switches and gas valve that shuts off fuel in the event of any utility failure, there are four safety interlocks:

1. Furnace heating chamber must be purged with NX gas *only* (to reduce combustibles to 4% or less) before interlock permits cover to be raised.

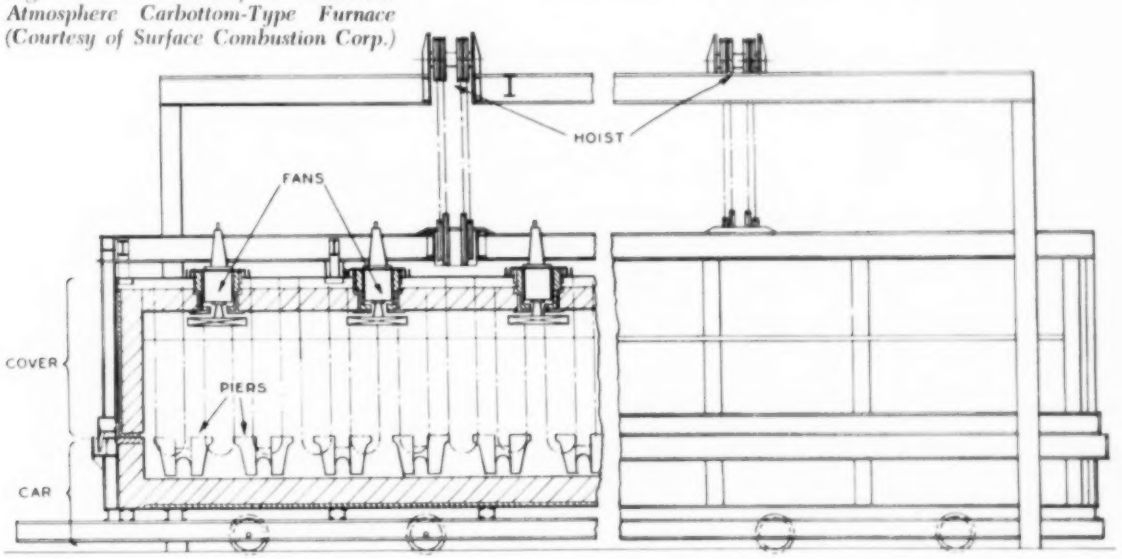
2. Either the NX or RX gas must be flowing into furnace and work temperature must be above 1200° F. before the valve for the enriching gas can be energized.

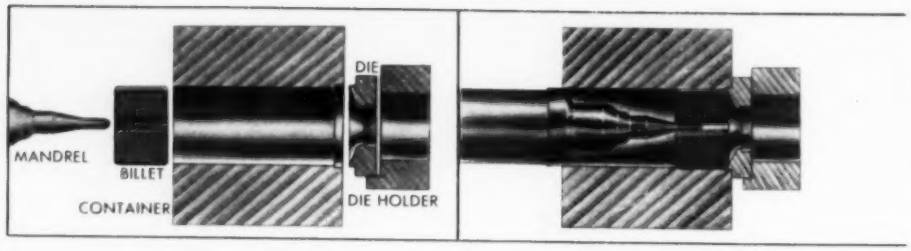
3. Work temperature must be 1400° F. before RX gas valve can be energized. This valve cannot be de-energized until a manual 3-way valve for NX-RX gases is turned to NX position.

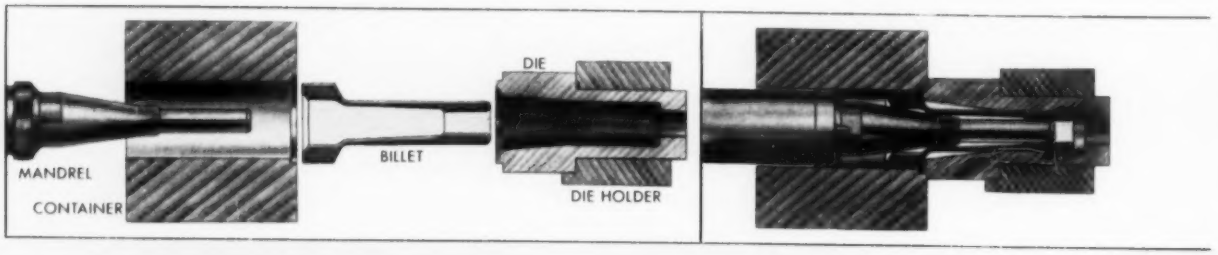
4. A warning horn signals the failure of controlled atmosphere pressure to the furnace heating chamber when the cover is down.

With these safeguards for equipment, personnel and processing, a highly efficient and versatile controlled atmosphere furnace is available for the varying demands of the Jones and Laughlin cold finishing department. Not only high quality but large quantity production is achieved at an over-all savings to both the customer and the steelmaker.

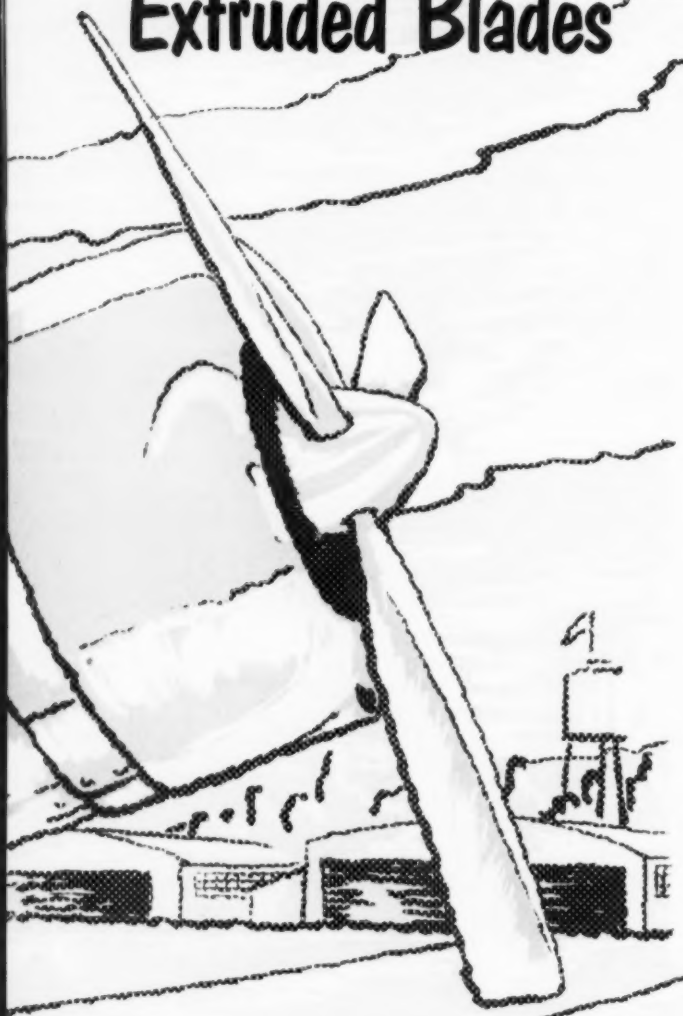
Fig. 4 – Cross Section of the Controlled Atmosphere Carbottom-Type Furnace (Courtesy of Surface Combustion Corp.)







Extruded Blades

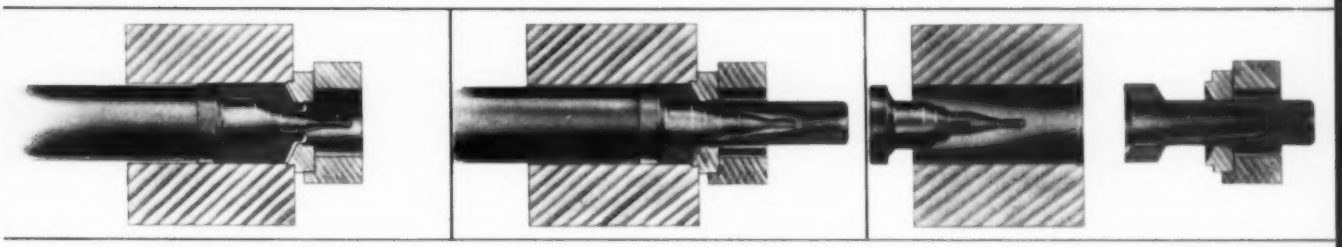


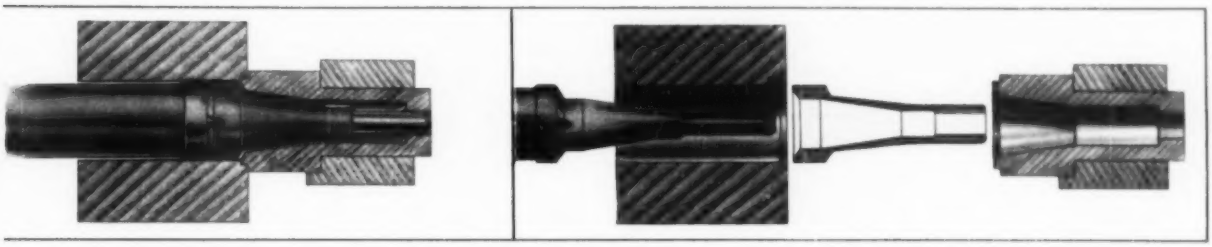
THE EXTRUSION of propeller blades by the Propeller Div., Curtis-Wright Corp., starts with the forming of the shank portion from a heated blank, as shown in the strip at top of page. This section is shaped to a uniform external diameter and tapered wall thickness.

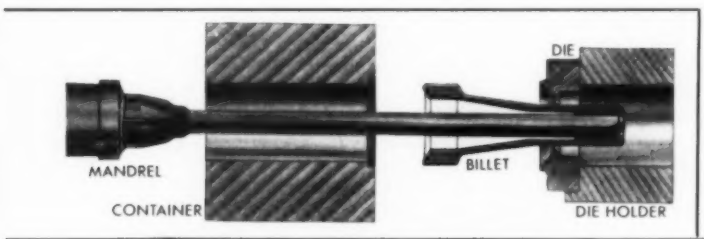
Second series of illustrations shows the expansion of the tapered section to the transition section between the shank and the airfoil portion of the blade. The shank portion is expanded as changed from a straight to a tapered diameter.

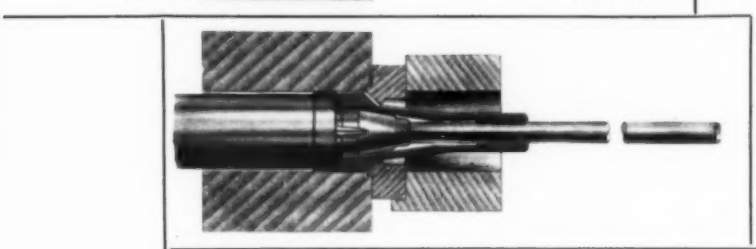
In the third operation, the reheated shank is extruded to the tubular blade section. The mandrel for this operation is tapered longitudinally so that during its advance, the orifice between mandrel and die is progressively narrowed to produce a tapered wall thickness. The tube is not round but has protrusions along its length on each side which are formed to the leading and trailing edges of the blade.

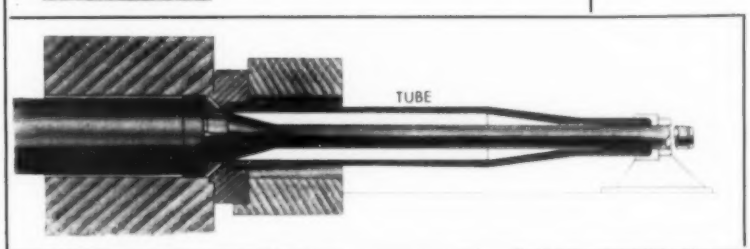
This tubular section, after machining of the shank and inspection, is flattened in a press to a blade of approximately the finished shape. Final airfoil and pitch distribution is obtained by inflating the heated blade with nitrogen under pressure while held in forming dies.

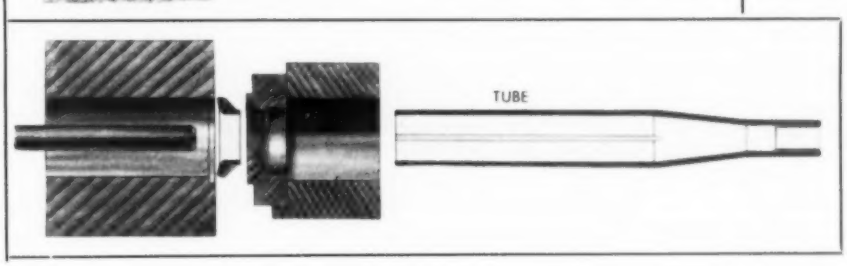












Advantages claimed for extruded over welded fabrication include greater strength and resistance to fatigue, lower production cost and greater output. Research for this method was sponsored by the Industrial Planning Division, Air Materiel Command, Air Force Development Center, Adrian, Mich.

The H-Bomb and Its Detection*

FROM THE official U.S. "Smyth Report" it is known that conventional atom bombs are really nuclear fission bombs, in the sense that the nucleus of an atom of natural uranium-235 or of the artificial element plutonium-239, when hit by a neutron (an uncharged particle of mass always existing in adequate numbers in the earth's atmosphere), will break into fragments and produce two or more neutrons. The total weight of all the resulting particles is less than the mass of the original atom, and the missing weight has been converted into enormous energy. One gram (one thirtieth of an ounce) of uranium atoms, completely fissioned, would liberate 8.2×10^{17} ergs of energy, equivalent to 23,000 kw-hr., or to the heat from burning 5400 lb. of carbon. The production of surplus neutrons insures continuance of the explosive reaction in the bomb if the mass of uranium or plutonium is large enough so that at least one of the evolved neutrons strikes another uranium nucleus before it escapes from the surface, and so on in a useful series.

Hence a small mass of U^{235} is safe; the explosion occurs when two safe, subcritical masses are joined together into one weighing (it is estimated) between 20 and 45 lb. The reaction is practically instantaneous; within a half-millionth of a second the mass is blown far apart so reaction ceases; efficiency is thus deplorably low, being on the order of 1%†.

Fusion Bomb — Go now from the heaviest of the elements to the lightest and we have the possibility of another series of nuclear reactions similar to that which energizes the sun and the stars — the *fusion* of four atoms of hydrogen into one atom of helium which weighs 99.3% of the original constituents; the rest emerges as energy. Since 0.091% of the uranium mass (in a 100% reaction) and 0.7% of the reacting hydrogen is converted to energy, a "hydrogen bomb" should be 7.5 times as powerful as a fission bomb, weight for weight. Reaction between atoms of ordinary hydrogen requires *very* high temperatures and pressures, such as exist in the centers of stars (and at the focus of a fission bomb), but is very slow, requiring millions of years. On the other hand, fusion of the heavier isotopes of hydrogen starts at much lower temperatures and the reaction needs only a small fraction of a second, as is shown by Hans Bethe in *Scientific American* for March 1950.

Of the six possibilities of reaction between atoms of hydrogen and its heavier isotopes deuterium $_1H^2$ and tritium $_1H^3$, the one which is the most significant to bomb makers is

$$_1H^2 + {}_1H^3 = {}_2He^4 \text{ plus a neutron.}$$

This can be set off fastest at a relatively low temperature, and generates the equivalent of 20,000 kw-hr. of energy for 1 g. of reacting substances. It is presumed that a fission bomb will supply the required temperature and pressure to start the reaction. Furthermore, while the energy of a uranium bomb is limited by the critical mass of the metal, there is no theoretical limitation to the dimensions of a fusion bomb since it cannot react spontaneously at ordinary temperatures. But how can a sufficient amount of these gases be made and placed at the focus of the explosion?

Production of Hydrogen Isotopes — As to heavy hydrogen ($_1H^2$), it has been made since the 1930's in Norway as a byproduct of fertilizer, manufactured by the synthesis of ammonia from its constituent gases. The hydrogen for this manufacture is derived from water by electrolysis. Water is H_2O, and has in nature about one part heavy hydrogen (sometimes called deuterium and symbolized as D) to about 6000 parts of normal or light hydrogen. The light hydrogen migrates to the anode at a faster rate than the heavy, so the electrolyte becomes progressively enriched in deuterium. In America, Urey and his associates (1932) were able to enrich water by fractional distillation; the light water boils out at 100° C. whereas pure heavy water has a boiling point of 101.4° C. and density of 1.108.

At about the same time the Farkas brothers discovered that when ordinary hydrogen gas (a mixture of much H_2 with a little D_2) is bubbled through water, about two thirds of the deuterium atoms in the gas displace the hydrogen atoms in the light water, and so enrich the liquid in "heavy" water. Since 1941 this reaction is believed to have been used on a large industrial scale in America. Water trickles down a tower through a powder metal catalyst, counter current to a mixture of hydrogen gas and very hot steam. The enriched gas reaching the end of a series of towers in cascade is then completely electrolyzed and the enriched hydrogen gas introduced again at the bottom of the tower — and so around and around until the desired concentration of heavy hydrogen has been reached.

* Extracts from a translation of an unsigned article entitled "Bombe H", in the French magazine *Atomes* for November 1953.

†EDITOR'S FOOTNOTE — The official explanation of an "atom bomb" as the quick conversion of two subcritical masses of U^{235} or Pu^{239} into one supercritical mass leaves one speculating about the techniques whereby "atomic bombs today are more than 25 times as powerful" as the first, to quote President Eisenhower's words. It is hard to see how three or more subcritical masses can meet simultaneously — that is, within a fraction of a millionth of a second. The subcritical mass could be much heavier if the metal were in the form of a long rod rather than a sphere, and so have much more surface area through which neutrons could escape, but this does not avoid the problem of converting a long wire into a solid ball instantaneously. Another scheme might be to interlace a supercritical mass with rods of boron which absorb all the neutrons in the vicinity, and to jerk these rods out at the proper moment. Still another booster would be to make the bomb of uranium or plutonium hydride, wherein the hydrogen is half deuterium and half tritium, to promote the fusion reaction of a true hydrogen bomb. Or, the expansion of the exploding mass might be delayed by a "tamper" — a shell or honeycomb structure of heavy metal which would act through sheer inertia. Would any of these, or any combination, be able to multiply a Hiroshima bomb 25-fold?

As to even heavier hydrogen — $_1H^3$, called tritium or T — it can best be produced by bombarding lithium ($_3Li^6$) with neutrons in an atomic pile. (This element occurs naturally, comprising 7.5% of metallic lithium, and it is unnecessary to separate the two isotopes.) The tritium gas so obtained may escape as such and be collected, or remain dissolved in the metal as gas, or combined as a hydride. After irradiation, the metal is dissolved slowly in water, giving up half of its tritium as gas, and half remains combined as lithium hydroxide. The latter portion may be recovered by heating with an alkaline metal. It is thought that the new Savannah River plant of the U.S. Atomic Commission is primarily occupied with this process.

At least ten other reactions which form tritium are known, but have not yet passed the laboratory stage. Tritium is unstable and has a half-life of about 12.5 years, so it cannot be stockpiled for long. It decomposes into $_2He^3$ and a beta ray (electron).

Hydrogen Bomb*—Assuming that a fission bomb should furnish the necessary heat to start the fusion of deuterium and tritium, how can enough of these gases be brought near the focus of the trigger-explosion to be effective additions? Even if carried in steel cylinders, say at 200-atm. pressure, the amount would still be small. If liquified at —250° C. the problem of transportation in a sort of thermos bottle would still be formidable. Mixtures of heavy water and tritium water seem a more likely combination; the oxygen would in fact give a useful inertia effect in preventing the bomb from flying apart so rapidly. Likewise, the uranium or plutonium itself might be pure hydride (half and half of $_1H^2$ and $_1H^3$).

Cobalt Bomb — Since "tampers" of high inertia are desirable to retain the reacting substances within the focus where reaction can continue for a few additional millionths of a second, it has been suggested that a thick case of cobalt or a high-cobalt alloy be used for such a casing. This cobalt would capture an important fraction of the neutrons liberated by the fission, instantaneously forming highly radioactive $_{27}Co^{60}$. This isotope, so useful when properly caged as a cheap substitute for radium, would be exceedingly dangerous when dispersed in the air. It emits very energetic gamma rays for a long time (its half life is 5.3 years). It would for the most part be brought to earth with the rain and be absorbed in the topsoil or run into the rivers.

While the mathematics involve several factors which are not precisely known, Arnold has computed that complete reaction of 200 tons of $_1H^2$ plus $_1H^3$ would produce about 2 tons of neutrons which could be captured to form as much as 80 tons of $_{27}Co^{60}$. This amount, if spread out uniformly in the topsoil of the earth, would emit radiations equal to about 10 roentgens per day, which is 100 times the continuous dosage now considered to be the maximum safe exposure.†

Detection of Nuclear Explosions — The most direct and obvious method is by harvesting the airborne products of the explosion and analyzing them.

Radioactive fission products — corresponding to the bomb-dust particles — from fission of uranium or plutonium have been intently studied. Their radioactivity plotted against time traces characteristic curves showing the rate of decay. Furthermore, the "background radioactivity" of Parisian air, to mention one example, has been continuously measured for some time by apparatus perfected by Labeyrie. A suction pump draws 200 liters of air a minute through a porous paper strip, which moves slowly past autographic instruments for measuring accurately the alpha, beta and gamma radiation. (Tests at definite time intervals give rates of decay.)

Similar methods, which have been used since radioactivity was discovered, have been utilized in the United States to study atmospheric dusts from their own explosions. Nowadays the physicist resembles a not-too-exacting wizard who, with some invisible particles from airborne dust, announces some days afterward that a nuclear reaction took place thousands of miles away!

The hydrogen bomb, in addition, would scatter large quantities of unused hydrogen isotopes. The radioactive tritium is detectable. Neutrons, also sent out in great quantity, react with atmospheric nitrogen, giving more tritium as well as radioactive $_6C^{14}$. Here, then, are two tell-tale characteristics of the H-bomb: $_1H^3$ and $_6C^{14}$.

An airborne apparatus is suggested wherein air is drawn through a metering venturi, then through filters to remove solids (whose radioactivity can be recorded continuously), next through caustic solution to fix the CO_2 (whose proportion of radioactive carbon-14 can be measured). The air then goes through an electric furnace to oxidize the tritium to super-heavy water; all moisture is then condensed and the radioactive portion estimated. As mentioned before, rates of decay of all these fractions are quite characteristic.

If a fusion bomb, as would be likely, would produce about 220 lb. of tritium, this amount distributed over France uniformly in 1000 meters of atmosphere would produce 400,000 disintegrations per cu.m. per min. — truly an enormous amount of radioactivity. Even after transportation for great distances by the winds, the dilution would not be so much but that the rise in radioactivity above background level could be readily detected.

* Editor's Footnote — All that has ever been officially stated about America's achievements is that a "thermonuclear reaction" has been tested. However, on Feb. 17, 1954, Representative W. Sterling Cole, chairman of the Joint Congressional Committee on Atomic Energy, stated that during the 1952 tests in the Eniwetok Atoll a "hydrogen device had completely obliterated" the test island. "It tore a cavity in the floor of the ocean — a crater — measuring a full mile in diameter and 175 ft. in depth at its lowest point." If this occurred in a modern city "the heat and blast would cause complete devestation over an area extending three miles in all directions. The area of severe-to-moderate damage would stretch four miles further — seven miles from ground zero."

† Editor's Footnote — Even though the efficiency of conversion or reaction in a bomb is on a very low order because of the limited time — maybe on the order of 1% — it is obvious that not very many "cobalt bombs" need be exploded to eliminate *all* the Russians and Chinese, as well as all the Americans, English and French.

The Blast Cleaning of Metal Surfaces

BLAST CLEANING as an industrial process has made tremendous strides since the days of the sand tumbling barrel. The equipment and abrasives now in use permit better cleaning of work at a greatly reduced cost. These benefits have resulted from the use of equipment and methods devised to suit the particular cleaning task. This report, therefore, will begin by defining the various methods and pointing out their applications. The methods divide into six categories:

Sand-Blasting – The application of dry silica sand or synthetic abrasives by the force of compressed air. This method is generally used where reclamation of abrasive is uneconomical or impossible.

Wet Sand-Blasting – Silica sand is mixed with water and propelled by compressed air. It is most suitable for marine applications, hull cleaning, and similar large surfaces of metal where all dust must be eliminated.

Shot-Blasting – Spherical metal pellets are driven either by centrifugal force or compressed air. A multitude of applications are possible.

Grit-Blasting – Angular metal pellets are driven by centrifugal force or compressed air. This process is used where the cleaned surface must have a bonding quality for some finish, such as galvanizing, enameling, phosphating and painting.

Hydro-Sand-Blast – Silica sand and water are mixed and applied under high pressure (1800 psi.) using water as the propelling agent. Used for removing cores in large castings and on surfaces of large pieces.

Liquid Blasting – A finely divided Arkansas silica of 100 to 5000-mesh or fine synthetic abrasive is suspended in a water solution and propelled by compressed air with a force of 40 to 80 psi. This method gives an extremely fine finish on tools, dies, molds and other items where surface quality and accuracy are highly important. Surfaces can be cleaned to tolerances of ± 0.0001 in.

Although each category has a particular field of application, in some instances several methods of blast cleaning can be competitive. Selecting the most efficient and economical method for a particular application requires consideration of five principal factors:

Type of Surface – When the surface that is to be cleaned is immovable – such as a ship's hull or a bridge which is to be repainted – it is necessary to use portable equipment, thus limiting the blast-cleaning agent to wet or dry sand. In this work, there is usually no possibility of reclaiming the abrasive and so metal abrasive would be prohibitive in cost. The abrasive used on work such as castings or forgings which can be brought to the machine can be reclaimed for re-use. The abrasives can be driven by compressed air for both kinds of work or by centrifugal force for the latter. Softer metals, as well as others which are blast cleaned for various reasons, are usually subjected to compressed air blasting with a non-metallic abrasive.

Quality of Finish Desired – No single type of metal abrasive or sand can perform all the jobs. There is a marked difference, for instance, between merely cleaning a surface and preparing it for a subsequent coating operation, such as galvanizing or enameling. Another requirement might be that every trace of sand or scale is removed to prevent dulling or breaking of high-speed tools in subsequent machining operations.

A great variety of decorative effects is possible on almost any hard surface through the use of different blast-cleaning operations. And where several categories will achieve the same results, there is the question of which will be most economical. This leads to the third factor.

Time or Speed of Cleaning – The time consumed by a cleaning operation is reflected directly in labor, power, abrasive consumption and maintenance costs per piece or pound of work processed. For example, malleable abrasives are more durable and economical than chilled iron abrasives, yet for certain cleaning operations (as in removing scale formed during heat treating) malleable abrasives are not as fast. Overhead and equipment depreciation are other factors.

A change in the total amount of work to be blast cleaned may require a change in the size and type of abrasive to be used. It may be necessary to increase production from a machine

By VICTOR F. STINE, Vice-President
Pangborn Corp., Hagerstown, Md.

which is already running at capacity with a fine grit. A coarser grit will give faster cleaning action, but with a rougher finish. It is also possible that a different type of abrasive will give faster cleaning. Increasing the air pressure or increasing wheel speed on airless blast cleaning will also decrease cleaning time. Care and experience are needed to select the proper abrasive for the required finish with least time.

Cost of Abrasives – Because the abrasive represents about 40% of total cleaning costs it is a factor of importance. Sand is the least expensive on a weight basis, but replacement is high and dust control is a problem. Chilled iron abrasives are also low in original cost, but this type breaks down more quickly than malleable grit and shot, and steel shot. Malleable or annealed abrasives are somewhat higher in original cost than chilled iron abrasives, but their longer life makes them the most economical abrasive, except in certain special cleaning operations.

Maintenance Costs – Cost of parts and labor for maintenance can represent from 25 to 60% of total cleaning costs; therefore, this factor is as important as finish and speed in the selection of an abrasive. Chilled iron abrasive, since it is comparatively hard, causes higher maintenance costs than the malleable which is softer. Whether air or airless (centrifugal wheel) blasting is specified will also determine wear on equipment due to the type of abrasive used.

Summing up all these factors, correct blast cleaning is achieved only if the required surface finish is obtained in the fastest possible cleaning time at the lowest abrasive and maintenance cost per piece.

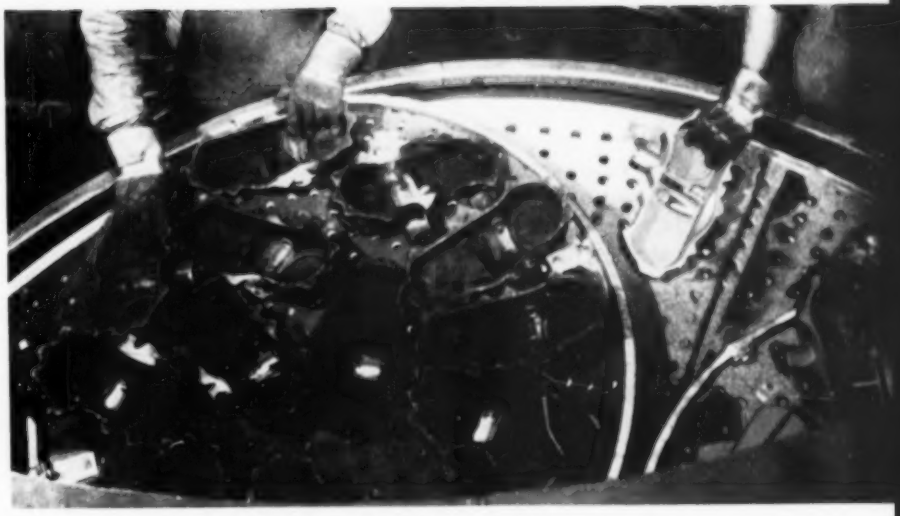


Fig. 1 – Small Castings Being Cleaned on an Air-Blast Table. Finished piece at right indicates the thoroughness of the cleaning operation

TYPES OF BLAST-CLEANING MACHINES

Blast cleaning has found such a variety of industrial applications that many types of machines have been developed. These machines can be classified in a general way according to the type of work for which they have been designed. There are machines which must be taken to the work. These are used for cleaning buildings, ship hulls, handling maintenance work in plants, and for cleaning large pieces (in the foundry or plant) which cannot be handled automatically. One group has been designed to provide rapid cleaning of like items. Castings, forgings and heat treated pieces are usually cleaned by these (Fig. 1).

Still another group has been designed to meet the requirements of large producers so as to handle a flow of work at a speed geared to factory output. These continuous type machines can be adapted to specific cleaning problems, but the basic principles of handling and cleaning remain the same. Machines are available for a particular type of specialty work, such as those for cleaning drums for repainting, and cleaning of armatures.

There are many different compressed air machines, but only three basic principles of blasting are involved – suction blast, gravity blast, and direct-pressure blast.

Suction Blast – A suction blast machine of the kind made by Pangborn Corp. consists of a blast gun, a hose between the gun and a feed box containing the abrasive, and a compressed air line to the blast gun. The blast gun is a trigger-controlled unit having an air jet and discharge nozzle, with space between for passage of abrasive.

As the compressed air expands from the smaller jet in the gun into the larger discharge nozzle, it creates a partial vacuum in the gun body. This suction draws the abrasive through the hose into the gun where it is mixed with the air blast and discharged at a velocity of

approximately 160 ft. per sec. for an air pressure of 80 psi.

The discharge nozzle is approximately twice the diameter of the air jet. When the compressed air expands into this nozzle (four times the area of the air jet), the original pressure head is reduced to approximately one quarter, except for the atmospheric air mixed with the compressed air in the blast gun. Even including the atmospheric air, actual pressure head at the top of the nozzle is very much reduced.

Suction blast involves low-cost equipment, but is the least efficient of the three systems employing the blast principles. Pressure head (with resultant low velocity) is sacrificed just to mix the compressed air and abrasive. Furthermore, only a limited amount of abrasive can be handled by the atmospheric air in the hose carrying the abrasive.

Gravity Blast – The principle of gravity blast is the same as for suction, except that the abrasive is elevated mechanically and fed to the blast gun by gravity. The same blast gun as for suction blast is used; however, more abrasive per cubic foot of compressed air can be discharged through the blast gun for increased surface coverage. Investment is somewhat larger than for the suction machine on account of the additional machinery.

Direct-Pressure Blast – The direct-pressure principle of blast cleaning requires a pressure tank. The tank holds abrasive under the same head of pressure as supplied to the compressed air line which carries the abrasive to the mixing chamber. When the pressure to tank and mixing chamber is balanced, the abrasive is discharged through the tip of the nozzle at original pressure head. Abrasive flow through the nozzle is approximately two to three times as great as with gravity blast and four times as great as with suction blast (about 240 ft. per sec. for an air pressure of 80 psi.).

In addition there are a number of machines that use a special mechanism to feed the abrasive from the direct-pressure tank to the compressed air line, and a nozzle by which the operator directs the abrasive stream at the work to be cleaned. The types of machines in this classification are as follows:

Automatic machines that are integrated with mechanized movement of the work and cleaned automatically. An example of this type of machine is shown in Fig. 2.

Air-blast barrels in which the work tumbles in a revolving drum as an abrasive stream is directed over it. These are generally used for batch cleaning of miscellaneous work.

Air-blast tables in which all but a sector of a housed revolving platform is exposed to the operator for loading and unloading the work (Fig. 3). After the work passes through a blast stream in the enclosed area it must be turned over for cleaning of the bottom surface on a second pass. Flat and fragile work is usually processed on a table of this type.

Air-blast cabinets for miscellaneous work that requires various amounts of cleaning or has deep recesses. The small cabinets for this kind of cleaning have a window for viewing the work as the operator manipulates it with glove-protected hands under the stream of abrasive.

Special machines are available for specific cleaning jobs involving large work and volume, as airplane propellers and interiors of shell cases. Often such machines utilize both compressed air and centrifugal force.

Air-blast rooms are special enclos-

Fig. 2 – Shot-Blast Machine at Ford Cleveland Foundry for Cleaning of 6-Cylinder Engine Blocks Employs Overhead Conveyer to Move Work Through Cleaning Zone

ures into which large work is carried by crane or by a car. The operators use protective clothing and an air-feed safety helmet while working in these rooms. Cleaning is done with a hose-type blast-cleaning machine.

ABRASIVE MATERIALS

Most industrial blast cleaning is done with metal abrasives because of their greater efficiency, longer life and a minimum of dust control problems. Of the several types of metal abrasives, cast iron shot is perhaps the most commonly known. It is inexpensive and is used where the carry-out loss precludes the use of more costly abrasives, regardless of their other advantages.

However, its low capacity for repeated impact results in relatively early breakdown; consequently, a larger quantity is required to do a given job than with costlier abrasives, such as malleable and steel shot. Wearing of parts in blast equipment is considerably greater with cast iron shot. The finish produced with cast iron shot, as with all spherical shot, is a surface having a multiplicity of rounded craters.

Cast iron grit (also called chilled iron) is the same material as cast iron shot. It is made by crushing cast iron shot and, particularly, the heavy slugs and irregular shapes that are formed during its manufacture. The angular nature of this abrasive imparts a good cutting ability which, as a result of the relatively fast breakdown of the abrasive, continuously exposes fresh cutting edges of extremely hard iron carbides. This cutting action is useful where extraneous material, such as fused-in sand, scale, rust, lacquer, enamel or other coatings, must be removed and where a "keying" surface is needed for subsequent finishing processes.

Malleable or annealed shot is a low-alloy shot malleableized to change the brittleness of the alloy shot to toughness, and to increase its durability under impact. Treatment also permits control of hardness and toughness. Although malleable shot and grit are expensive, their higher cost is easily offset by their longer usefulness. Consumption for a given amount of work is in a ratio of 1 to 2 or 1 to 3 with cast iron shot or grit. The parts subject to wear give 50 to 75% longer service when malleable shot or grit is used. Greater savings are obtained by using malleable grit or shot in the airless (centrifugal wheel) type of blast-cleaning equipment.

Steel shot has the structure and the combination of hardness and toughness to withstand repeated impact much better without fracture or excessive wear than cast iron and malleable shot. This resistance to fracture accounts for its 200 to 400% increase in life over that of chilled iron abrasives. Also, steel shot is hard enough to do the job, but soft enough to be easy on the equipment. The wearing parts of blast-cleaning equipment usually have a Brinell hardness of 450 to 550, while that of cast or chilled iron abrasives is from 450 to 680. Hence the rapid wearing of the equipment. The hardness of steel shot, however, is held to less than Brinell 450, yet it works as fast or faster than conventional cast iron abrasives. Its greater durability results in a lower cleaning cost per unit in spite of its considerably higher initial cost.

Steel shot is also produced by clipping (shearing) steel wire with rotary cutters to a length approximately the same as the diameter of the wire. The sharp edge and the pointed lip of dragged metal at the sheared face cause rapid wear of parts in the blast machine. Eventually the cylinder is reduced to a fairly symmetrical ball, and the spherical shape is retained

(Continued on p. 142)

Fig. 3 – Design of Air-Blast Table ("Rotoblast") Allows Two Men to Work Simultaneously, One to Load While the Other Unloads Cleaned Pieces

By LORIN K. POOLE,
Metallurgical Engineer
Arcos Corp., Philadelphia

Sigma—an Unwanted Constituent in Stainless Weld Metal

STAINLESS STEELS and weld metals of austenitic microstructure, as commercially made in America, undergo certain microstructural changes in service at elevated temperature, which alter their hardness, strength, ductility, and corrosion resistance, one of the more important of which is the precipitation of what metallographers call "the sigma phase". It is hard, nonmagnetic and brittle. When isolated from the main body of the alloys, the particles give an X-ray diffraction pattern characteristic of the iron-chromium alloy containing equal atomic percentage of iron and chromium – such as would be contained in a hypothetical compound FeCr. The pattern suggests a tetragonal crystal structure with 30 atoms per unit cell, although other work indicates an orthorhombic unit cell of 24 atoms.

Sigma phase – or at least microconstituents of the above general characteristics – is by no means limited to iron-chromium systems. The tendency of binary systems to form sigma phase seems to be governed by the atomic diameters of the reacting atoms, which must agree within 8%. Furthermore, one of the elements must have a body-centered cubic and the other a face-centered cubic crystalline habit. Though not always designated "sigma", such a phase is also identified in the binary systems Fe-V, Cr-Co, Cr-V, and Ni-V and in ternary systems based on them.

Sigma phase in susceptible stainless steels – the topic of this review of known facts – is precipitated between 1000 and 1700° F., the exact range varying somewhat in different compositions. Elements commonly added to stainless steels, to stabilize the carbide, to enhance creep and stress-rupture properties, or for deoxidation in the steel mill, seem to widen the temperature range for the precipitation of sigma. These

As is well known to metallurgists, many of the high chromium-nickel austenitic steels used for their heat resistance (slow scaling in ordinary furnace atmosphere) are "metastable" and new microconstituents appear during service.

One of the most exasperating intruders into weld metal is "sigma phase". One might say the sure way to avoid this is to use electrodes so high in alloy that the austenite is not metastable but stable – and this is the view taken by some prominent European metals engineers. However, welds made with them inherit another serious trouble known as "hot short cracking", so you're out of the frying pan into the fire. American engineers generally prefer the frying pan, and Mr. Poole gives a good summary of what can be done about sigma phase in austenitic weld metal.

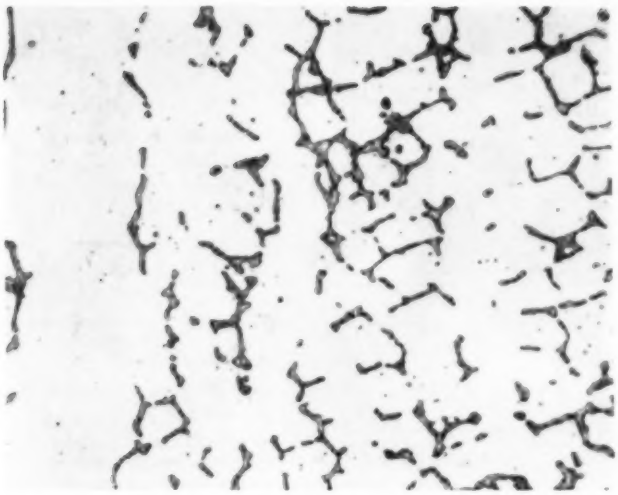


Fig. 1 – Complete Transformation of Ferrite to Sigma in a Type 347 (18-10-Cb) Weld Deposit After Aging 8 Hr. at 1300° F. Sodium cyanide electrolytic etch. 1000×

elements include molybdenum, columbium, titanium, and silicon.

Unfortunately for the welding engineer, the most extensive investigations into the formation of sigma and its effects on stainless steel have been made on *wrought* materials. Since weld metals are inherently more heterogeneous in nature and since the metal in a weld may not necessarily have the same initial microstructure as the base material, the available knowledge about the mechanism of formation of sigma and its effects cannot be applied directly from the wrought compositions to weld metals and joints. Therefore the welding engineer must rely for the most part on information obtained from the examination of welds which have been in service, or those which have been examined after only relatively short-time exposures in the laboratory to elevated temperature.

Formation – Sigma in weld metal can apparently be formed by two different mechanisms. In weld deposits containing some ferrite (solid solution of iron, chromium, nickel and carbon crystallizing in the body-centered cubic system) sigma will appear in the ferrite areas in the weld metal. This type of transformation is illustrated in Fig. 1, which shows sigma transformed from the ferrite islands after 8 hr. at 1300° F. in a Type 347 stainless weld metal (18-10-Cb).

Second, sigma may be formed directly or indirectly from austenite and occurs principally at the grain boundaries. This occurs

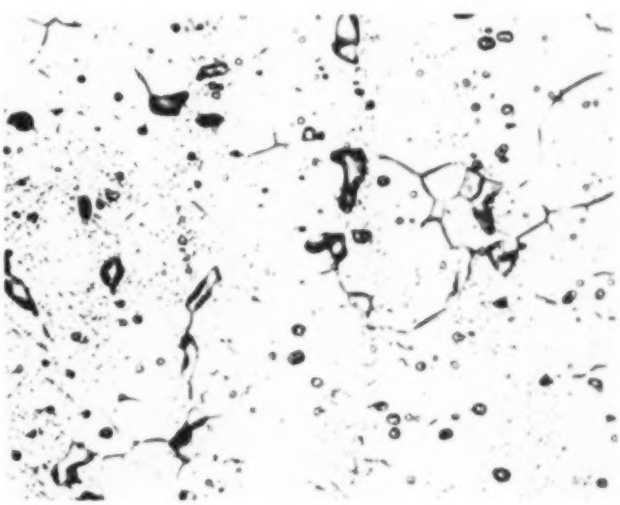
Mechanism of Formation

in some "fully austenitic" grades. This second type of transformation is shown in Fig. 2, illustrating sigma in cold deformed Type 310 weld metal (25-20 Cr-Ni) after 108 hr. at 1600° F.

The rate of formation by these two mechanisms is vastly different. When transformation occurs from ferrite (Fig. 1) approximately 12% of sigma (measured as area of the micrograph) had been formed after only 8 hr. exposure to elevated temperature; however, much more than 108 hr. would have been required to produce the same amount of sigma from the fully austenitic composition of Fig. 2 – even after severe deformation, which markedly increases the transformation rate. (The sample shown in Fig. 2 was taken from the necked portion of a 0.505-in. tensile bar. The threaded end of the same piece, which was also heated for the same time, did not show enough sigma to be detected metallographically except at the edges, where some cold deformation occurred as a result of machining the threads.)

In both modes of transformation the rate depends on both time and temperature. The effect of time follows the expected pattern,

Fig. 2 – Sigma Phase Transformed From Austenite in a Type 310 Weld Deposit (25-20 Cr-Ni) After Aging 108 Hr. at 1600° F. Oxalic acid electrolytic etch. 750×. The mottled constituent in the grain boundaries is sigma phase



Rate of Sigma Formation

namely, increasing amounts of sigma are formed with longer times, but at rates which progressively lower as equilibrium is approached. Figure 3 shows this effect of time at 1100° F. on the conversion of ferrite to sigma as judged by the lowered amount of ferrite and the change in hardness and bend elongation. The sample was a 29-9-Cb (Type 312-Cb) stainless weld deposit.

The effect of temperature, however, does not follow the pattern we would expect in actions which depend solely on diffusion. The fastest generation of sigma occurs not at the *top* of the temperature range but about midway between the maximum and minimum temperatures at which it can be formed. Thus, the effects of 2 hr. at temperature (and a prior 1950° F. quench) on the ferrite-to-sigma change in the weld metal examined by Emerson and Morrow (described in the caption of Fig. 3) are illustrated in Fig. 4.

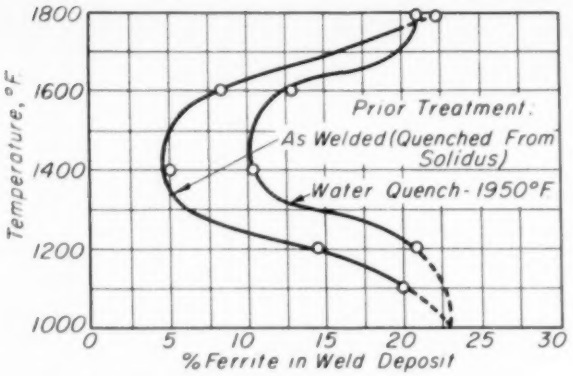


Fig. 4 – Sigma Forms Fastest (Remaining Ferrite Is Reduced to Lowest Amount) at Temperatures Midway in the Susceptibility Range. All specimens heated 2 hr. at temperature after prior treatment as noted (Emerson and Morrow)

The rate and amount of sigma formed are also apparently dependent on the quantity of ferrite present in the weld deposit. This effect at 1600° F. is shown in Fig. 5, taken from Emerson and Morrow's work on two low-ferrite welds in Type 347 (one manual and one submerged-arc) and one high-ferrite submerged-arc weld in Type 312-Cb. Two samples of the latter were studied, one as-welded, and the other water quenched from 1950° F.

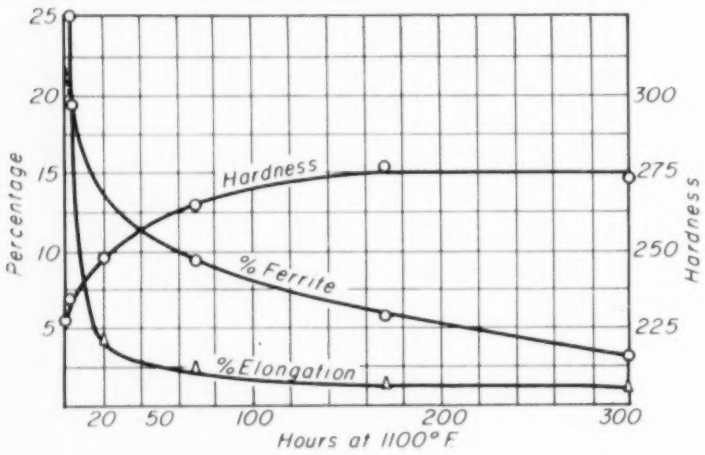
Three different ferrite levels in Type 316 weld deposits (17-12-2.5 Cr-Ni-Mo) have been studied in our own laboratory to determine the effect of heat treatment on sigma formation and the resulting loss in bend ductility. As seen in Fig. 6, the embrittlement caused by the transformation of ferrite to sigma increases with the original ferrite content. The fully austenitic composition does not embrittle during the times and temperatures of test.

The beneficial effect of low ferrite in Type 347 weld metal, as judged by Charpy 45° V-notch specimens aged at 1150° F., is shown by a study made at Public Service Electric and Gas Co. (N.J.) wherein two samples were studied. Sample 1 had less than 3% ferrite originally and Sample 2 had 9%. After aging 1000 hr. at 1150° F., both samples contained less than 0.5% ferrite as determined by Magnegage. Presumably the rest of the ferrite had transformed into sigma, and Sample 1 with less sigma than Sample 2 had considerably higher impact strength. The same was true after stress-relieving (SR) 4 hr. at 1350° and aging as above.

No.	Condition	Ferrite	Charpy Impact
1	As welded	2.8%	63.5 to 67.5
2	As welded	9.0	60.0 to 67.5
1	Aged	0.5	15.0 to 31.5
2	Aged	0.5	5.5 to 7.5
1	SR and aged	0.5	11.0 to 25.5
2	SR and aged	0.5	5.5 to 7.5

Sigma embrittlement of 0.505-in. tensile specimens cut from Type 347

Fig. 3 – Showing the Effect of Time on Precipitation of Sigma. Sample was 29-9-Cb weld deposit, heated at 1100° F. Increasing amount of sigma is shown by lowered amount of ferrite in the microstructure, the hardening and the loss in elongation in free bend (% in 0.5 in.). Brinell hardness is converted from Rockwell B. Data by Emerson and Morrow, Welding Journal Research Supplement, *January 1951*



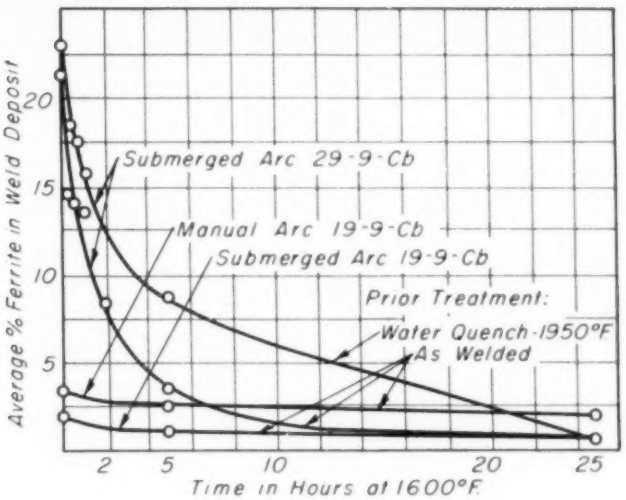


Fig. 5 – Nearly all of the Ferrite in a High-Ferrite Weld Is Transformed in 25 Hr. at 1600° F., Whereas Half or Less Is Transformed in a Low-Ferrite Weld (Emerson and Morrow)

weld metal (18-10-Cb) of different ferrite content after exposure to high temperature is shown in Fig. 7. Figure 1 shows the sample with 12% ferrite. The 50% loss in ductility can easily be understood in view of the fact that the hard, brittle sigma constituent is oriented in an almost continuous pattern.

Very little has been published on the effect of sigma in completely austenitic weld metal. However, two failures attributed to sigma formation have been reported by Geerlings and Vollers, to the Third World Petroleum Congress at The Hague in 1951. One failure occurred after 3200 hr. in service (temperature not given) in a Dubbs furnace, in a weld containing 23.8% Cr and 18.4% Ni, and was attributed to loss of ductility due to sigma formed in the grain boundaries. The second failure occurred after 50,000 hr. service in a weld metal containing 23% Cr, 18% Ni, and 0.81% Mo; again, sigma was in the grain boundaries and was reported to be the cause. Annealing at 1150° C. (2100° F.), and then water quenching, increased the impact properties of these two welds from 2.8 to 15.6 kg-m. per sq.cm. and from 1.9 to 8.8 kg-m. per sq.cm., respectively.

CONTROL OF SIGMA

The deleterious effects of sigma phase in partially ferritic weld metals may be counteracted in two ways. The first attacks the problem at its source and controls the ferrite content. The second aims to correct the damage by a heat treatment which eliminates as much of the sigma as possible.

The ferrite content can be controlled by carefully "balancing" the austenite-forming and the ferrite-forming elements in the composition of the electrode core wire or by adjusting the nature of the coating.

A method of controlling – even eliminating – sigma phase in castings has been suggested by J. H. Jackson in A.S.T.M. Special Publication No. 110 (1951) and is worthy of note by the welding metallurgist: The austenite-forming elements are increased to the upper limits, or the ferrite-forming elements are decreased to the lower limits of the specifica-

Fig. 6 – Ferrite-Free Welds of Type 316 Are Not Embrittled – no Sigma Is Formed – in Treatments Which Markedly Affect Samples With 5 to 8% Ferrite As-Welded (Schaeffler, Transactions, 1950, p. 978)

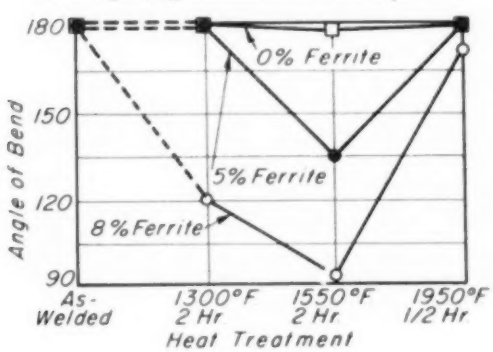
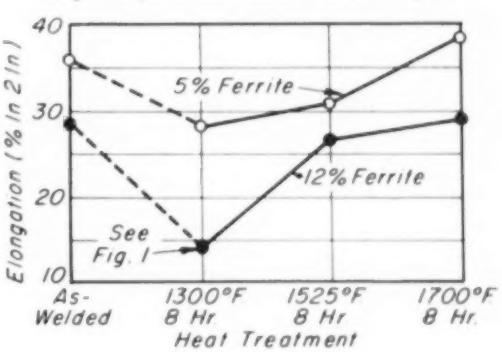


Fig. 7 – Relationship Between Original Amount of Ferrite in Type 347 Weld Metal (18-10-Cb), Its Heat Treatment in the Susceptible Range, and Its Ductility as Measured by Elongation in Tensile Test (Schaeffler)



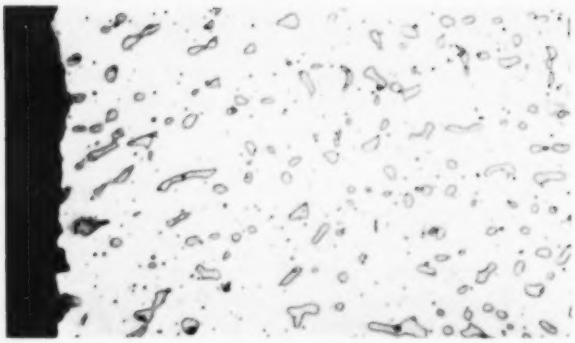


Fig. 8 – Ferrite Spherulites Formed in Type 316 (17-12-2 Cr-Ni-Mo) Weld Metal by Soaking 1 hr. at 1950° F. Followed by Water Quenching

tion – or both. Such a composition would have a narrow temperature range for sigma formation. Some borderline compositions may be sigma-free, and possess a stable austenitic phase. Since it is generally believed by American specialists that some ferrite is necessary to prevent weld cracking in certain grades of stainless weld deposits, the welding metallurgist must employ this method of controlling sigma with caution because the amount of ferrite may be decreased below the minimum amount necessary to prevent cracking.*

A weld originally with low ferrite retains much more of its original toughness after heating in the susceptible range, as shown by the figures tabulated on p. 110 for Type 347. The beneficial effect of heat treatment at 1920° F., as indicated by Charpy 60° V-notch tests made by General Electric Co.'s staff on weld metal embrittled at 1350° F., is shown below:

Condition	Ferrite	Charpy Impact	Brinell Hardness
As welded	10%	23 to 25	225
1 hr. at 1920° F.*	5	26 to 29	180
2.5 hr. at 1350° F.†	6	10 to 11	240
Above two in succession	3	27	190

*Water Quenched †Air Cooled

The beneficial effect of heat treatment at 1920° F. (*above* the temperature for sigma formation) followed by water quenching is believed to be due to solution of some of the preexisting ferrite into the austenite and to the agglomeration or spheroidization of the remaining ferrite. Sigma later formed from ferrite spherules would be in a discontinuous pattern and have less effect on the properties of the matrix, as shown in the last line of the above tabulation and in the microstructure of Fig. 8.

Control of sigma in fully austenitic weld metals susceptible to sigma formation is a serious problem, since the brittle constituent is formed principally in the grain boundaries. As more and more sigma grows during high-temperature service, sigma gradually forms a continuous network. Thus ductility is lost, especially when the service temperature is in the lower range of susceptibility. At the high border of the susceptible range the particles are more agglomerated and less continuous, as observed in Fig. 2, and consequently are less damaging to the ductility.

The only well-established method for controlling sigma in susceptible fully austenitic weld metals is periodic high-temperature heat treatment. This either agglomerates or puts the sigma back into solution, depending on the time and temperature used. This expedient is, of course, undesirable from the practical standpoint and sometimes impossible.

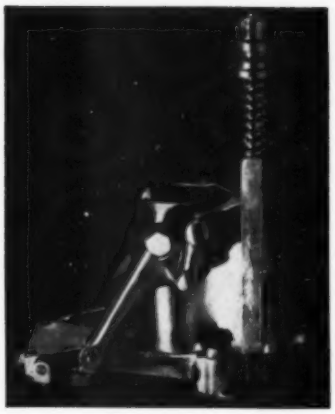
High-temperature impact tests indicate that presence of sigma does not embrittle these alloys *at service temperatures* as much as at room temperature. However, the room-temperature properties cannot be regarded lightly, since stresses resulting from cooling and heating during shut-downs, and any thermal cycling, would require good properties at lower temperatures to prevent failures.

IDENTIFICATION OF SIGMA PHASE

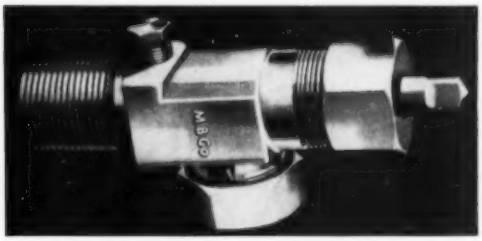
Identification is complicated by the fact that when sigma occurs in very fine particles it is difficult if not impossible to distinguish from finely divided carbides. In the author's experience, if the sigma particles are large enough to appear as circles or islands at 1000 magnifications, they can be reliably identified by various etching techniques reported by G. N. Emmanuel in *Metal Progress* for July 1947, p. 78, and J. J. Gilman in *Transactions*, 1952, p. 566.

X-ray diffraction can positively identify the sigma constituent, but it must first be isolated or selectively concentrated. Some interference from tetragonal chromium carbide (Cr_7C_3) and columbium has been reported. X-ray methods suffer from the fact that the particle size and distribution in the original matrix cannot be determined. These factors are important, since large particles of sigma segregated at grain boundaries are much more effective in lowering mechanical properties than an equal amount of sigma evenly distributed in fine particles.

*Contradictory reports have been published concerning the function of 2 to 3% copper in ordinary heat resisting compositions. One is that 2 to 3% copper will slow down the sigma transformation in Type 347. Another is that copper may decrease the ductility, if other conditions – especially ferrite content – are equal.



Durable . . . bottle-capping unit uses cast Nickel-Silver. (Courtesy of Universal Castings Corp., Chicago, Ill.)



Corrosion-resisting . . . chlorine gas cylinder valve body of Nickel-Silver. (Courtesy of Mueller Brass Co., Port Huron, Mich.)

Nickel-Silver

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Durable...yet easy to cast or fabricate, machine and polish

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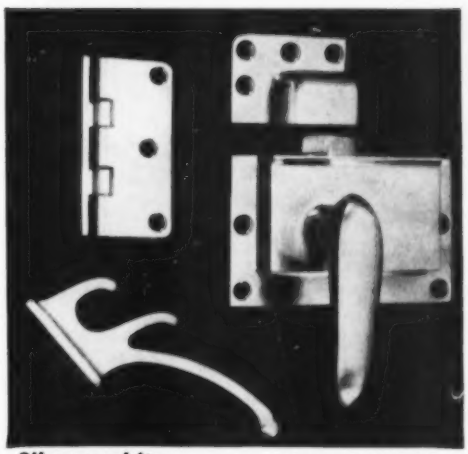
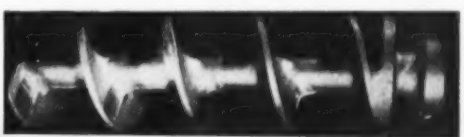


Silvery white . . . wear-resistant Nickel-Silver fixtures for railway passenger cars. (Courtesy of Loeffelholz Co., Milwaukee, Wisc.)



Readily cast . . . packaging machinery components of Nickel-Silver. (Courtesy of Arthur Harris & Co., Chicago, Ill.)

Versatile . . . Nickel-Silver used in cast valve for meat-packing machine. (Courtesy of Lakeside Bronze, Inc., Buffalo, N. Y.)

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Wrought Aluminum Alloys

Compositions, Properties, and Designations of American Commercial Alloys

Revised November 1953

Compiled by F. M. Howell, Aluminum Co. of America, and H. S. Jerabek, University of Minnesota, June 1953, from handbooks and specifications of the principal manufacturers, the American Society for Testing Materials, and the Society of Automotive Engineers.

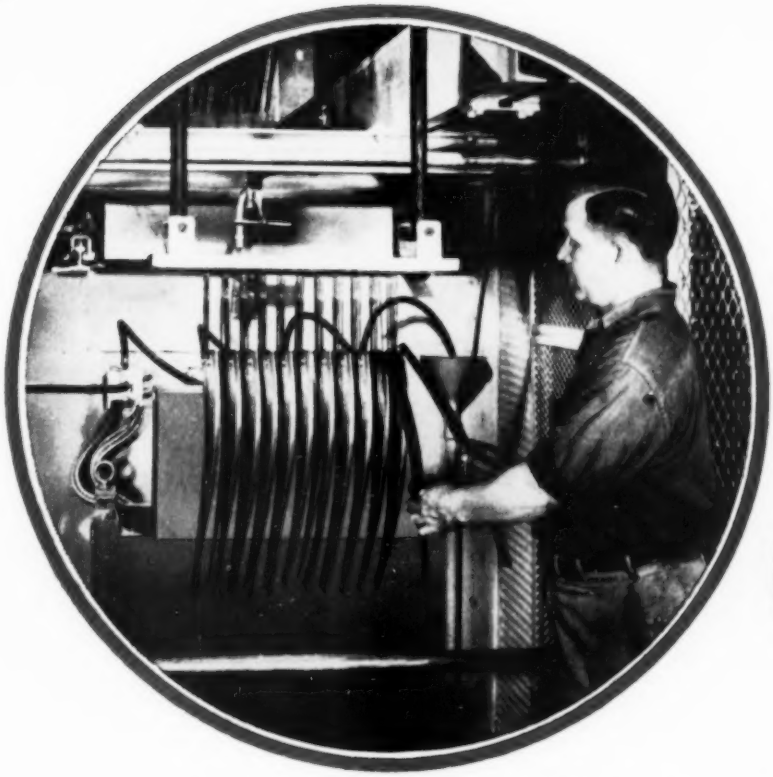
	Designations				Nominal Composition Aluminum = Balance						Condition	Tensile Strength (c)		Yield Strength (c)		Elongation, % in 2 In.		Brinell Hardness	Shear Strength	Endurance Limit (d)	Cold Bending (e)	Corrosion Resistance (f)	Characteristics and Uses
	A.S.T.M.	S.A.E.	A.M.S. (b)	Alcoa (a)	Cu	Si	Mn	Mg	Cr	Zn		Av.	Min.	Av.	Min.	Av.	Min.						
Work Hardenable Alloys	996A			CD1S-0 CD1S-H14 CD1S-H18	(99.6 Al Min.)						1/16" Sheet	10 14 19	(13 Max) 12 16	4 13 18	 10 13	43 12 6	25 10	19 26 35	7 9 11	3 5 6.5	A B F	A A A	Excellent forming qualities, corrosion resistance and weldability; pressure vessels and chemical equipment.
	990A	25	4001B 4003B	2S-0 2S-H14 2S-H18	(99.0 Al Min.)						1/16" Sheet	13 17 24	(15.5 Max) 16 22	5 16 21	 14 19	35 9 5	30 5 4	23 32 44	9.5 11 13	5 7 8.5	A B F	A A A	Commercial Al; good forming properties and corrosion resistance. Spun hollow ware and cooking utensiles and sheet metal work.
	M1A	29	4006B 4008B	3S-0 3S-H14 3S-H18			1.2				1/16" Sheet	16 21 29	(19 Max) 19.5 27	6 19 26	 17 24	30 8 4	25 5 4	28 40 55	11 14 16	7 9 10	A C G	A A A	Similar to Alloy 2S, slightly stronger and less ductile. Chemical equipment, tanks, cooking utensils and sheet metal work.
	MG1IA			4S-0 4S-H38			1.2	1.0			1/16" Sheet	26 40	(29 Max) 38	10 34	 30	20 5	18 4	45 77	16 21	14 16	B G	A A	Fairly high strength, fair forming properties; tubing and sheet.
	G1A			5OS-0 5OS-H38				1.4			1/16" Sheet	21 32	(24 Max) 29	8 29	 24	24 6	20 4	36 63	15 20		B G	A A	Moderate strength and forming properties, good corrosion resistance.
				A5OS-0 A5OS-H34 A5OS-H38				0.8			1/16" Sheet	17 23 30	(20 Max) 20 26	6 20 28		28 8 4	22 6 4	28 41 51	11 13 17		A C G	A A A	Similar to 3S with better appearance after anodizing, decorative articles.
	GR20A	201	4015C 4017C	52S-0 52S-H38				2.5	0.25		1/16" Sheet	27 41	(35 Max) 39	12 36	 31	25 7	20 4	45 85	18 24	16 20	B G	A A	High strength, fair forming properties, sheet, plate, wire, rod, bar, pipe and tubing.
	GR40A			A54S-0 A54S-H38				3.5	0.25			34 48	45	16 39	34	27 8	18 5			17 21		A A	New highest strength not heat treatable alloy; sheet for welded construction.
			4182	56S-0 56S-H38			0.1	5.2	0.1		Wire	42 60	(46 Max) 55	22 50	10	35 15		65 100	26 32	20 22		A B	Wire, screening and rivets; high strength and corrosion resistance.
				C57S-0 C57S-H34 C57S-H38			0.3	1.0			1/16" Sheet	19 25 32	(22 Max) 22 28	7 22 30		25 8 6	20 5 4	32 45 55	12 15 18		B C G	A A A	Anodized articles requiring bright uniform appearance.
Heat Treatable Alloys	CG42A	24	4035B 4037B	24S-0 24S-T4 24S-T36	4.5		0.6	1.5			1/16" Sheet	27 68 72	(32 Max) 62 69	11 48 57	(14 Max) 40 52	19 20 14	12 17 12	47 120 130	18 41 42	13 20 18	B J K	E D D	High strength, Dural-type alloy available in almost all wrought forms. T36 temper strain hardened after soln. heat treatment.
	Clad CG42A		4041B	Clad 24S-T4 Clad 24S-T86								64 70	58 66	42 66	37 62	19 6	11 3		40		K	A A	Clad with coating of 99.3% min. aluminum. T86 soln. h.t., strain hardened and artificially aged.
	GS11A	281	4025B 4026A 4027A	61S-0 61S-T4 61S-T6	0.25	0.6		1.0	0.15		1/16 Sheet	18 35 45	(22 Max) 26 38	8 21 40	(16 Max) 16 35	22 22 12	16 16 10	30 65 95	12.5 24 30	9 13.5 13.5	B E F	B B B	Very good forming properties, fair strength, intermediate corrosion resistance, all wrought forms, except forgings.
	Clad CS41A			Clad 14S-T6	4.4	0.8	0.8	0.4				68	64	60	57	11	8		41		K	B	Clad with 0.7% Si, 1.3% Mg, 0.25% Cr alloy.
	ZG62A		4044 4045	75S-0 75S-T6	1.6			2.5	0.3	5.6	1/16" Sheet	33 82	(40 Max) 77	15 72	 66	17 11	10 8	60 150	22 49	24	D K	E D	Highest strength commercial alloy, forming properties somewhat inferior.
	Clad ZG62A		4049	Clad 75S-T6								76	72	67	62	11	8		46	13	J	A	Clad with 1% Zn, bal. Al.
	CS41A	260	4153	14S-T4	4.4	0.8	0.8	0.4			1/2" Extrusions	70	64	60	58	13	7	135	42	18		D	High strength extrusions with fair ductility.
	CG42A	24	4152D	24S-T4	4.5		0.6	1.5				68	60	48	44	19	12	120	41	20		D	Strong extrusions with good ductility.
	ZG62A		4154C	75S-T6	1.6			2.5	0.3	5.6		89	90	79	72	10	7	150	49	24		D	Highest strength extrusions, fair ductility.
	GS11B	282		53S-T6		0.7		1.3	0.25			37	32	32	25	13	10	80	23	13	G	A	Good corr. resistance. Architectural and marine uses.
	GS11A		4150A	61S-T6	0.25	0.6		1.0	0.25			45	42	40	35	17	10	95	30	13.5		B	Good strength and workability, high corr. resistance.
	GS10A		4156	63S-T6		0.4		0.7				35	32	31	25	12	8	73	22	9.5		A	Best workability and corr. resistance in this group.
	CP60A			11S-T3	5.5		(0.5 Pb)			(0.5 Bi)	1/2" Rolled Rod	55	45	48	38	15	10	95	32	18		D	Free cutting, screw machine products.
	CM41A	26		17S-T4	4		0.5	0.5				62	55	40	32	22	16	105	38	18		D	Original Duralumin composition now largely replaced.
	CS41A		4135F	14S-T6	4.4	0.8	0.8	0.4			1/2" Forgings		65		55		10	125	42	18		D	High-strength forging alloy.
	CN42C	270	4140C	18S-T6	4			0.6	(2 Ni)			61	55	46	40	12	10	120	39	17		D	Good strength at elevated temperatures, aircraft cyl. heads.
	CN42D		4142	B18S-T72	4			1.5	(2 Ni)			48		37		11		95	30			D	
	SG121A	290	4145D	32S-T6	0.9	12.2		1.1	(0.9 Ni)			55	52	46	42	9	5	120	38	16		C	Forged aircraft pistons, high temperature strength.
	SG11A	280	4125C	A51S-T6		1.0		0.6	0.25			48	44	43	37	17	12	100	32	11		B	Moderate strength, best forgability.
	ZG62A		4137	76S-T6	0.6		0.5	1.5		7.5			70		60		14	140	39	17		E	High strength and corrosion resistance, aircraft uses.

(a) Commercial alloy numbers of Aluminum Co. of America. S=wrought alloy. Temper designations: O=Annealed, H18, 28, 38 (formerly H)=hard rolled; H14, 24, 34 (formerly 1/2H)=half hard; T4=soln. h.t.; T6=soln. h.t. plus artificial aging, T72=soln. h.t. and stabilized.

(b) A.M.S. Aero. Material Spec. of the Society of Auto. Engineers.

(c) In thousands of psi. Yield strength taken at 0.2% permanent set.

(d) 500 million cycles in reverse bending. (e) Relative forming properties in cold bending, A=best. (f) Relative resistance to corr., marine exposure, A=best.



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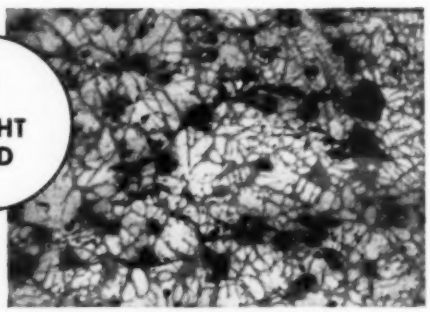

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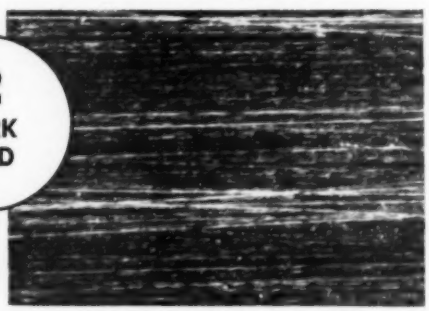

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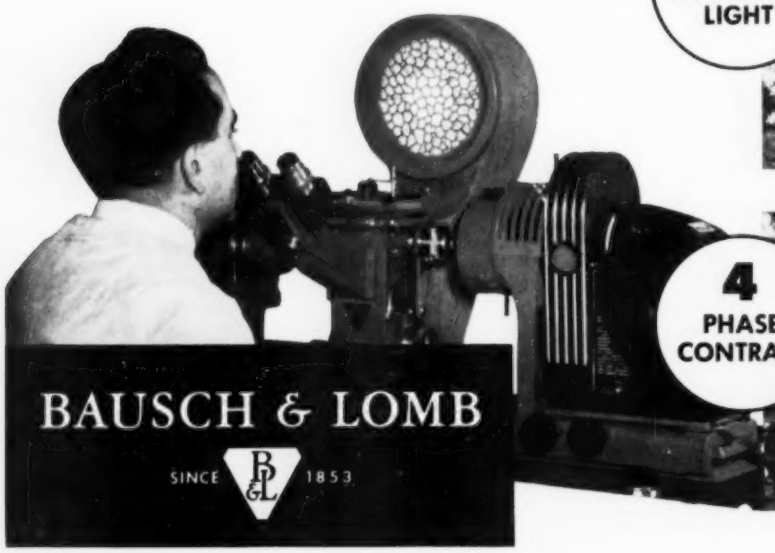


Critical Point

by the Editor

Aluminum Everywhere!

FOLLOWING an informal talk on "New Metals" before a large and appreciative audience at an ⊜ Pittsburgh Chapter meeting, the Editor spent a day with old friends on Alcoa's staff. Aluminum, by the way, could readily be classed among the "new" metals, since its common use not only awaited the advent of cheap electric power and the organizing genius of American business, but also a determination to experiment, experiment, experiment with new applications, alloys, finishes, manufacturing methods. New Kensington is now, as it always has been, the center of the company's organized research, and the laboratories have expanded from the modest quarters in the "Wearever" utensils factory occupied in the 1920's to the group of buildings on the hill, most excellently equipped with men and machinery.

One of the youngest departments there is in charge of L. M. Foster (who was a wartime member of the "Metallurgical Laboratory" at University of Chicago), and is devoted to work requiring radioactive materials, secured principally from the Atomic Energy Commission, but sometimes from the cyclotron at the University of Pittsburgh. The growing pains of this youthfield of metallurgical research are intensified in the aluminum industry because a number of the important chemical elements with which it is concerned—aluminum, oxygen, fluorine, carbon, silicon, magnesium—do not have useful radioactive isotopes which can be produced by irradiation in an atomic reactor. This actually turns out to be a fortunate situation since trace materials—contaminants or deliberate additions—can be activated without interference from the bulk of the sample.

Research in this new department at New Kensington is not confined to metals. Much "conventional" work on lubrication applies primarily to machinery in Alcoa's own mills. However, by the use of radioactive journals, wear has been determined in the micro-inch range . . . Flow of metal in extrusion is being followed by inserting tiny plugs of radioactive metal into the billet and then locating their presence in the finished bar or in the metal remaining behind in the cylinder . . . Radioactive elements are useful to the chemist, both for evaluating existing analytical methods and providing independent determinations for trace elements. For example, by activation analysis, where the element is made radioactive in the pile and hence measurable with extreme sensitivity, sodium was determined in aluminum and alumina with high precision even though it occurred in the third or fourth decimal place. Phosphorus was determined in 0.1 g. of alumina to ±0.000,000,1 g.!

Another problem that besets the aluminum metallurgist is the detection and location of oxide and dross entrained in the metal. Aluminum oxide itself cannot be made radioactive, but by adding a minute amount of radioactive sodium the oxide absorbs it and is "tagged". Autoradiography then reveals the location of the oxide. A related line of work has to do with imperfections in the naturally formed oxide film. If the continuity of this film could be measured, it would help in an understanding of the behavior of aluminum in corroding mediums—since corrosion usually starts at such imperfections. Radioactive mercury is the reagent

New Alcoa Building in Downtown Pittsburgh

Reception Foyer on a Typical Office Floor Uses Much Aluminum for Trim and Furniture

here, a metal with an extraordinary ability to penetrate defects in the oxide that are invisible under the microscope.

Autoradiography is a principal tool in such work and R. C. Plumb (who has immediate charge of tracer work) has made some notable improvements. As is well known, the technique consists of squeezing a fine-grained photographic film down on the surface under study, and later developing the film; black spots or gray areas locate the radioactive regions. However, the radioactive source may be deep below the metal's surface; likewise, the film darkening may be "deep" within the film. Hence—make both film and metal as thin as possible. Eastman Kodak has taken care of the first requirement with a film 0.0004 in. thick and grain so fine it will stand several hundred enlargements. Plumb met the second by cementing the sample (maybe 0.2 x 0.4 in.) on the slightly dished bottom of a steel cup, and then grinding and polishing both sample and can-bottom until the sample is no more than 0.0004 in. thick!

Later in the day, we inspected Alcoa's beautiful new office building in downtown Pittsburgh where the company's favorite metal has been used in many new ways. The exterior sheathing is ¼-in. thick "No. 5 Alumilite Sheet" which has a surface cladding of 5% silicon alloy and was anodically coated to a gray color. Acoustical ceilings are 0.040-in. perforated aluminum sheet, the sections clipped over a grid of ½-in. aluminum piping carrying 125° heating water in winter and 65° cooling water in summer. All of the heating and half the cooling is provided through these pipes; the balance of the cooling is from circulated air.

Window frames, interior trim of all sorts, doors, electrical busses, cables, conduits, wires, lighting fixtures, water piping, air ducts, furniture—all together (plus the use of light-weight "perlite" concrete curtain-wall back-up) have so cut the dead weight that this 30-story building needed only 6500 tons of structural steel for its skeleton in comparison with 12,700 for the neighboring Gulf Building and 10,000 for the Oliver Building, both closely similar in height and rentable area.

Among the many innovations which will draw the study of progressive architects are the aluminum lighting fixtures ("Alzak" finish on the reflectors) built to tolerances of 0.01 in. for tight contact with their support—the supports are, in fact, the piping network in the ceilings, so the heat from the lamps can be taken directly away in the circulating water. Sanitary engineers also will observe that 60% of the piping is aluminum, joints heliarc welded (to avoid flux). Steel pipe and cast iron fittings are used for steam, condensate or waste lines which are likely to be contaminated with salt or caustic, and where steel pipe is ordinarily used.

Likewise, small-diameter runs leading to individual services use copper pipe with brass valves and plumbing fixtures, principally because all-aluminum equipment of this sort is not manufactured as yet. At the start of each run a short piece of thick-walled aluminum pipe is inserted (properly insulated from the main line). This sacrificial section, which will take all the damage from electrolytic corrosion, can be readily replaced at proper intervals—15 years, more or less.

Most of these important details are hidden. The admiring visitor's attention is for the most part focused on the beautiful and harmonious interiors, using glass, synthetics, fabric, wood, marble, and (you guessed it) aluminum—embossed, enameled, anodically coated, colored, and just plain.

Modern Stainless Steels*

By ROBERT H. ABORN
Assistant Director of Research
U. S. Steel Corp. Research Laboratory
Kearny, N. J.

IF STEELS have personalities, then the ones we are to consider here are indeed the glamour girls of this steel age. From the gleaming liquid in the electric furnace to the silvery product in any of a host of applications, they demand (and receive) the maximum of attention which their value warrants.

Compared to ordinary steels, stainless steels are manufactured in relatively small quantity. But there is this outstanding difference: While the tonnage steels and iron all over the world are reverting to brown rust by the thousands of tons every day, the stainless steels, fabricated into articles of beauty and utility, will endure for decades to come without any elaborate provision for protection. It is partly for this reason that relatively expensive stainless steels can, with definite proven economy, replace ordinary steels, and thereby eliminate some part of the world's annual corrosion loss estimated now at more than $2 billion per year.

Has it ever occurred to you that many of the most prominent "stainless steels" are neither "stainless" nor "steels" in the generally accepted sense of these two words? Under some conditions they certainly will stain and most of them are not hardenable by heat treatment. Undoubtedly more accurate terms would be corrosion resistant or heat resistant iron alloys, but convenience and brevity have dictated the adoption of the simpler term.

Present Position – Although Faraday in England and Berthier in France made chromium-iron alloys 130 years ago and reported their resistance to corrosion, this information lay dormant for some 90 years, until it was rediscovered just before World War I, almost simultaneously in Germany, France, England and America. The first American commercial heat, a cutlery steel, was made in 1915. For ten years commercial production was negligible, but in 1926 adoption in the first synthetic nitric acid plant brought it prominently to the attention of industry. Since 1935, stainless steel production has risen almost continuously, and in the past fifteen years has increased tenfold, whereas total steel production has fluctuated widely and in the corresponding period has only doubled. The rounded figures in net tons of ingots are:

YEAR	STAINLESS	ALL STEEL
1935	80,000	36,000,000
1945	545,000	75,000,000
1953	1,015,000	110,000,000

The present production ratio of total steel to stainless is about 100:1 but the dollar value ratio is only 15:1 owing to the special raw materials and processing required in the latter. Expressed in actual dollar value, almost $500,000,000 worth of stainless steel is being produced this year (1953) in contrast to almost none 30 years ago.

Distribution of Uses – Now what becomes of it? Only part of it reaches the market owing to inevitable losses in conversion from ingot to salable forms. The uses of these finished forms are myriad but they may be grouped into a few broad fields. Its distribution among these fields depends on whether our national economy is predominantly civilian or defense, as is shown in Fig. 1, comparing the distribution for 1949, the most recent year of civilian economy, with that of 1953 (a "defense" economy year). Of the steel available for civilian use, automobiles consume about one third, with other forms of transportation, building, food processing and home equipment using another third. Chemical uses, though prominent in a civilian economy, are included in the current defense block,

*1953 Woodside Lecture (editorially condensed) presented before the Detroit Chapter, Oct. 12, 1953.

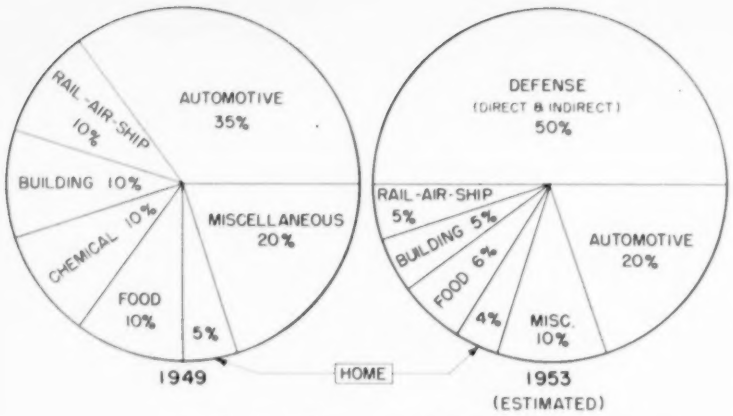


Fig. 1 — Distribution of Stainless Steels in America Depends Greatly Upon International Tensions. Compare 1949 (peacetime) with 1953 (cold war).

as they generally require the austenitic nickel grades now under rigid Government allocation.

Manufacturing processes are essentially the melting and refining of high-chromium iron alloys. Experience and understanding of particular metallurgical principles are of unusual importance, because of two peculiarities of chromium — its strong affinity for carbon as well as for oxygen. Carbon is usually a nuisance (as will be explained) but the strong attraction of chromium for oxygen is essential, being responsible — strange as it may appear — for the high corrosion resistance of stainless steels. Nearly all stainless steel is made in basic-lined arc furnaces in heats of 5 to 100 tons.

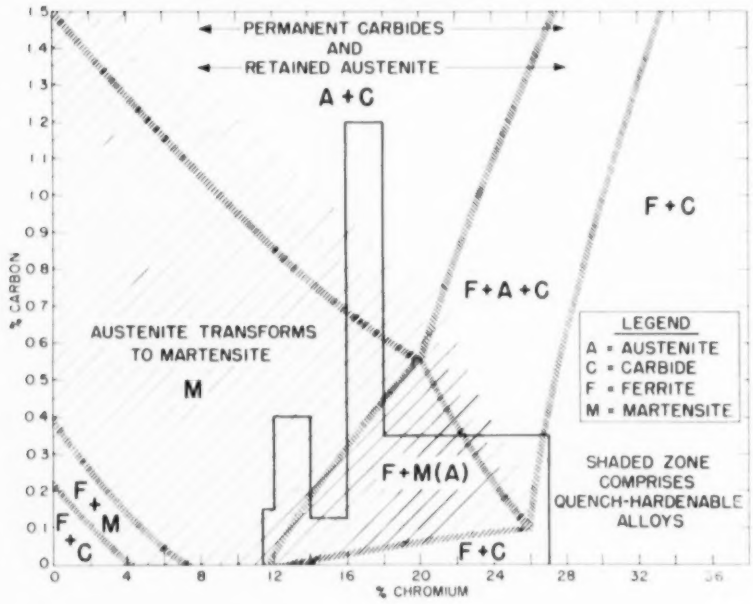
Several major advances in manufacture have been made since World War II. For example, oxygen is blown into the molten bath to accelerate oxidation, thereby raising the temperature so that carbon oxidizes faster than chromium. Thus, the time per heat is reduced and recovery of chromium increased. For such reasons effective use of stainless scrap has been increased from 25 to 75% of the charge.

An essential feature of steelmaking practice which differentiates it from most low-alloy practice, is the almost complete removal of carbon to insure the lowest practicable content in the final steel. (A few grades require higher carbon.) Until recently this top limit has been about 0.08% carbon for the more corrosion resistant austenitic types.

However even they, without titanium or columbium, are vulnerable to intergranular corrosion in certain environments after welding or hot forming.

This vulnerability has been eliminated by the discovery of economical means of reducing the carbon still further — to less than 0.03% in Types 304 L (19-10) and 316 L (17-12 Mo). This represents an achievement of the first order, because of the extreme difficulty of reducing carbon to such a low level in the melt, and the even greater difficulty of maintaining that low level through subsequent conversion to the finished forms, since chromium has extreme avidity for carbon even from the atmosphere. Extra-low-carbon stainless was achieved first by melting, in a specially lined furnace, a charge of plain low-carbon steel scrap along with nickel or other metallic oxides and blowing it with oxygen to as low as 0.01% carbon before deoxidizing and refining. Its manufacture has been aided by the recent development of ferrochromium pellets, containing silicon and silica and less than

Fig. 2 — Iron Corner of Iron-Chromium-Carbon System, Showing Microstructures Existing in the Alloys After Quenching From Temperatures of Maximum Austenite. Solid lines from 11 to 27% Cr outline compositions of commercial steels, with two "towers" comprising Types 420 and 440



0.02% carbon, which readily dissolve in the steel bath. These reduce the heat time and allow the use of the conventional magnesite furnace lining, conducive to greater cleanness.

The very recent addition of small amounts of rare-earth metals or oxides of the cerium group to improve hot workability first led to somewhat erratic results, but the picture is now clearer. Either oxide or metal additions appear to be capable of extending the working range of stiff, high-alloy austenite of Type 310 (25-20 Cr-Ni) and of helping to equalize the stiffer austenite and softer ferrite in alloys with mixed-phase microstructure such as Types 316 (17-12-2 Mo), 317 (19-12-3 Mo) and 309 (23-14). However, the rare-earth additions have not noticeably reduced the annoying hot shortness of the newer high-manganese stainless steels developed to replace some of the nickel stainless steels during the present shortage.

The most significant recent development in processing technology is the successful adaptation of primary rolling mills and continuous hot strip mills for carbon steel to the conversion of stainless ingots.

Structure Types – Some 50 varieties of "stainless steels" fall into three families:

1. Chromium-iron alloys with 11 to 18% chromium (carbon going up with the chromium), which are true steels in the sense that they harden on quenching – that is to say, are then martensitic alloys.

2. Chromium-iron alloys of lower carbon content which are not hardenable by heat treatment – that is to say, are ferritic alloys containing carbide.

3. Chromium-nickel-iron alloys which have high enough alloy to exist as austenite – that is to say, a nonmagnetic solid solution, of face-centered cubic crystallography.

The matter is further complicated by the fact that many of the austenitic alloys are borderline or metastable, in the sense that other microconstituents will form in the metal during unfavorable fabrication or service conditions.

Figure 2 diagrams the basic microstructure of quenched chromium-iron-carbon alloys. The varied behavior stems of course from the opposing action of carbon and chromium on austenite at high temperature, carbon promoting and chromium discouraging its formation. Complete martensitic hardening in stainless steels can be achieved only when the chromium content is below 20%, for the entirely austenitic field (marked M in Fig. 2) disappears at that value. Maximum obtainable hardness, as always in steels, increases with amount of carbon dissolved in the austenite, but the ability of austenite to dissolve carbon decreases as its dissolved chromium increases. Furthermore, corrosion resistance increases – within limits – as more chromium is dissolved. Thus, the cutlery grade, with about 17% chromium and 0.7% carbon, may represent the best compromise obtainable when aiming for the keenest cutting edge and highest corrosion resistance.

An important effect of adding chromium, often overlooked, is that although it generally discourages austenite at high temperature, it has a strong tendency to *retain* austenite once formed. Consequently, martensitic stainless cutlery and bearings may have much retained austenite, and steel with 20% chromium and 0.6% carbon may be quenched wholly austenitic except for undissolved carbides.

Turning now to the austenitic class, their most striking characteristic is the opposing influence of chromium and nickel on the result-

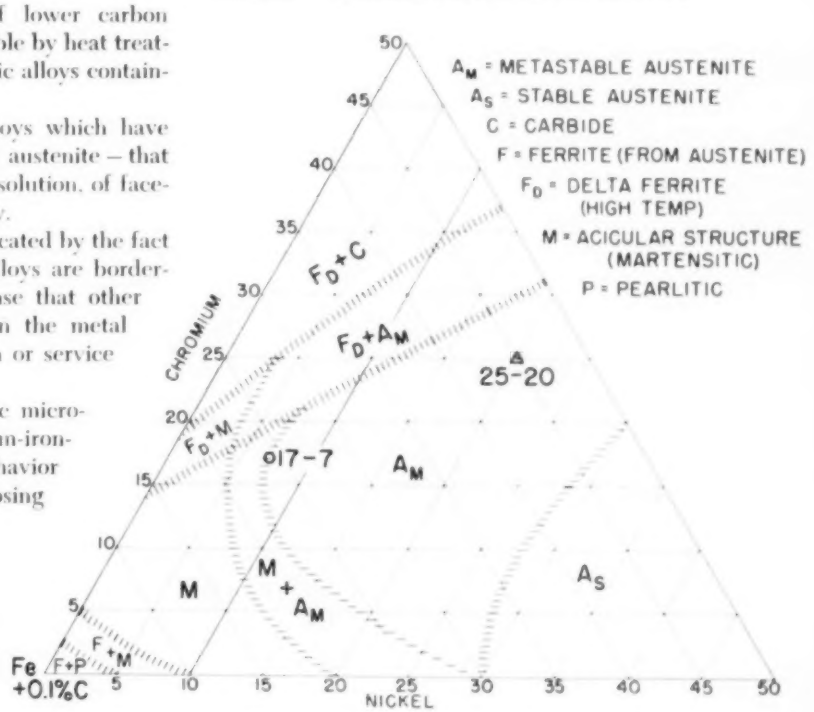


Fig. 3 – Iron Corner of the Iron-Chromium-Nickel Structural Diagram Showing Conditions in Alloys Containing 0.10% Carbon After Quenching From Temperatures of Maximum Austenite

ing structure. The result is a compromise, with nickel contriving to stabilize austenite at intermediate temperatures, and chromium managing to stabilize ferrite at very high and low temperatures. This sounds like a return to the characteristics of iron itself, but there is one outstanding difference, namely, a tremendous reluctance to change at any lower temperature unless acted upon by external forces. This is the most important fundamental characteristic of the majority of the chromium-nickel austenitic steels.

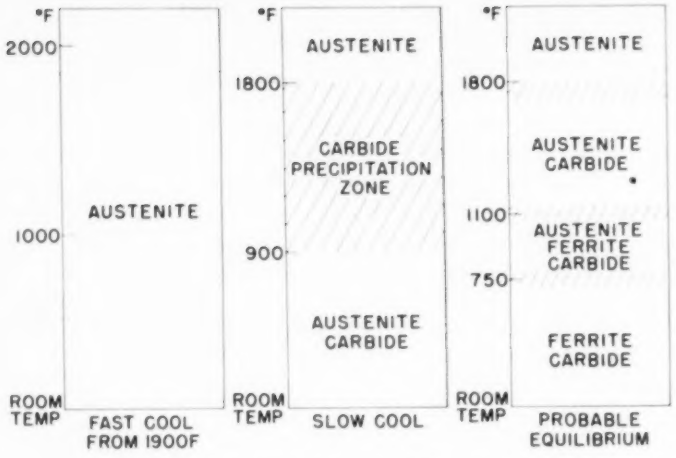


Fig. 4 — Constitution-Temperature Charts for 18 Cr, 8 Ni, 0.10 C Steel During Quenching, During Slow Cooling, and Under Conditions of Probable Equilibrium

Figure 3 shows what happens when the Fe-Cr-Ni alloys (with 0.10% carbon) are rapidly cooled to room temperature after the usual austenitizing treatment at 1900 to 2000° F. Only those lowest in chromium and nickel have transformed. There is a large field labeled A_M for metastable austenite, which means that although ferrite is the truly stable phase, the mobility of the iron atoms is so restricted by the dissolved chromium and nickel atoms that the austenite is unable to transform spontaneously. Note that 17-7 (Type 301) is in the twilight zone nearest the austenite-martensite field, so it can be easily persuaded to transform by nudging the atoms, whereas 25-20 (Type 310), far removed from this twilight zone, is very reluctant indeed to change.

Now, selecting the deservedly popular 18-8 alloy for closer study, one can observe the effect of the most commonly applied treatments. Figure 4 contrasts microstructures after fast and slow cooling with probable equilibrium (approachable by cold work, as discussed later).

Sigma phase is a complex, brittle, chromium-iron compound which can form at elevated temperature. The conditions are incompletely understood, and its rate of formation varies enormously with composition. In plain 18-8 it rarely ever occurs, but almost any additional nickel or chromium increases sigma susceptibility — particularly if ferrite is present. Thus, high-chromium ferritic grades require rapid cooling from the annealing temperature to be sigma-free. The highly alloyed Type 310 is so susceptible, after cold working and low annealing at 1700° F., that a third of the structure may consist of sigma.

It has recently been discovered that what has been regarded as sigma phase in the molybdenum grades (Types 316 and 317) has a different crystal structure and accordingly has been named chi. Its effects can be just as detrimental. Both intruders are most damaging as a thin network, and least so as massive islands. Their high hardness has been successfully utilized in Type 329 with about 24% chromium, 4% nickel, 2% molybdenum and 0.4% carbon, which can be "sigmatized" to a diamond penetration hardness approaching 600 (a hardness reported to be retained even in prolonged service up to 1000° F.).

The higher-chromium ferritic grades, when held between 800 and 1000° F., are subject to another structural change known as "885° F. embrittlement" associated with marked hardening and loss of ductility. As with the formation of sigma and chi, the action is reversible and normal properties can be restored by heating to a sufficiently higher temperature. At our Kearny Laboratory we have recently discovered that the embrittling agent is a chromium-iron phase considerably richer than sigma in chromium and of a different crystallographic system. The particles shown at 60,000 magnifications in Fig. 5 could only be detected with a new electron microscope technique.

CHEMICAL PROPERTIES

If the alchemists had found a piece of iron immune to rusting in a damp atmosphere, they would undoubtedly have searched for a hidden "noble" metal as the necessary converting agent.

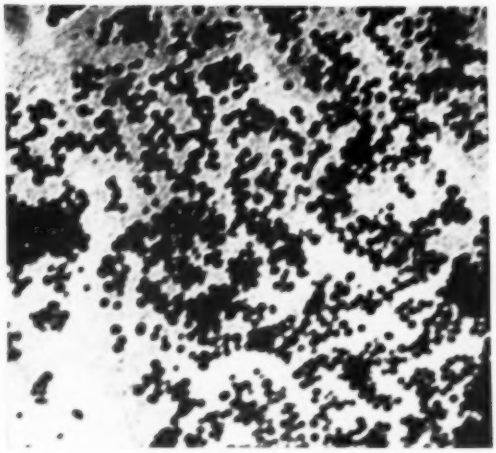


Fig. 5 – Chromium-Rich Particles Extracted From 27% Cr-Fe Alloy Suffering From 885° F. Embrittlement. Metal had been exposed to 900° F. for 4 years. Largest particle, about one millionth of an inch, would be rated No. 28 on A.S.T.M. grain size scale. Electron micro at 60,000 × made by technique described by Fisher, Dulis and Carroll in Journal of Metals, *May 1953*

How far from fact! The real agent is that chameleon of metals – chromium – in partnership with oxygen. Stainless is more noble than iron in such oxidizing environments as nitric acid, and less noble in strongly reducing environments such as hydrochloric acid. This example of relative inertness or passivity contrasted with extreme chemical activity is *the* outstanding property of the stainless steels.

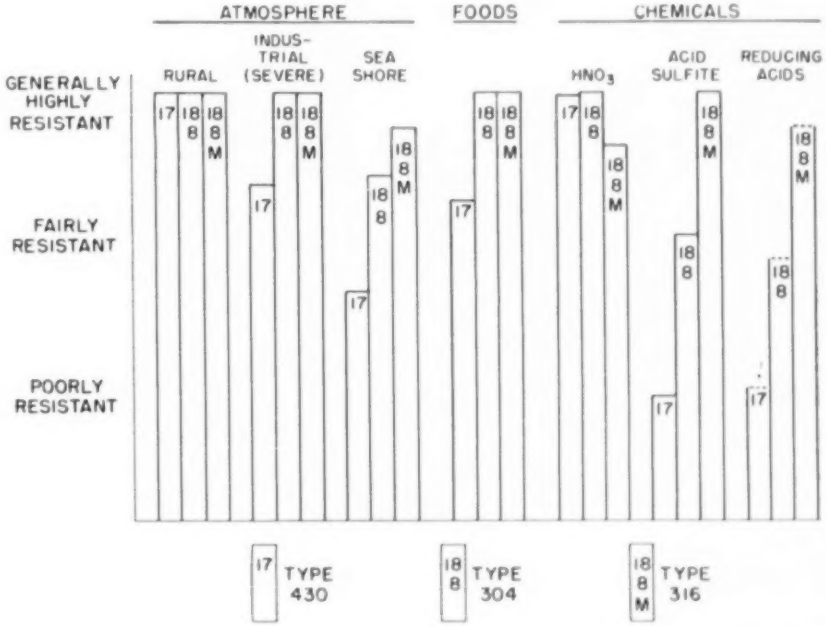
Protective Film – To account for this passivity three mechanisms have been proposed: *(a)* an oxide film; *(b)* oxygen gas absorbed by chromium atoms in the surface layer; *(c)* favorable electron sharing between iron and chromium, aided by absorption of oxygen, and hindered by hydrogen.

For our purposes we adopt the first hypothesis. The contrast between activity and passivity can be explained most easily by the absence, or presence, of a protective film whose existence depends on a continuing supply of chromium and oxygen atoms. Such a film, less than a millionth of an inch thick, has actually been isolated. The concentration of chromium in the film is higher than in the metal, and both film thickness and chromium content increase with increasing polish. These observations account very well for the practical fact that the higher the polish the better the corrosion resistance will be.

Passivity appears sharply when the dissolved chromium exceeds about 11% and improves gradually with increasing chromium content. It is important to note that the chromium must be *available* – that is, dissolved in the iron rather than locked in a compound. The addition of nickel and especially molybdenum markedly improves corrosion resistance in weakly oxidizing, neutral and mildly reducing environments, as illustrated in Fig. 6.

Pitting and Crevice Corrosion – The formation and maintenance of the protective film represents a constant battle between oxidizing and reducing forces, and always there must be fresh reserves of oxygen to plug the holes. The chloride ion is an insidious enemy, for it infiltrates at weak spots in the film and helps form

Fig. 6 –Except in Nitric Acid Service, Addition of Molybdenum Provides the "Tiffany" of Stainless Steels – the Equal or Superior of 18-8 in Any Service, Markedly Superior in Sulphurous, Sulphuric, Phosphoric Acids and Acid Salts, and Hot Organic Acids Such as Formic, Acetic and Fatty Acids



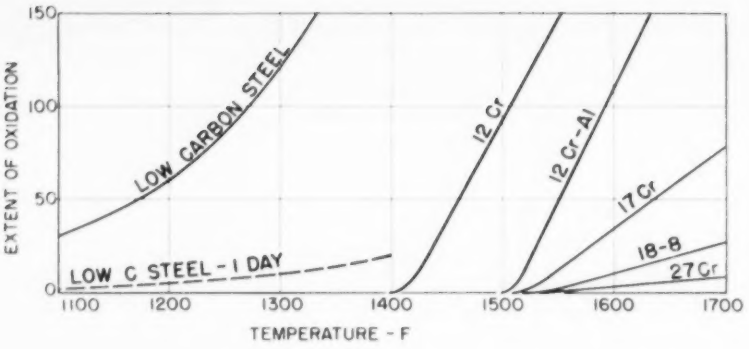


Fig. 7 – Rate of Scaling Is a Function of Chromium Content, Time and Temperature. Curves are for 1000 hr. in air; extent of oxidation is measured in weight gain (mg. per sq.cm.). Maximum temperature without excessive scaling is as follows:

Type	Temperature
Carbon steel	1000° F.
12% Cr; Type 410	1250
12% Cr+Al; Type 405	1300
17% Cr; Type 403	1550
18-8; Type 304	1650
27% Cr; Type 446	2000
25-20 Cr-Ni; Type 310	2000

minute pits. The oxygen content of the relatively stagnant electrolyte at the bottom of the pit is soon depleted, making the bottom anodic to the surface around the pit, thereby deepening the pit until eventual perforation occurs.

Another manifestation is the so-called crevice corrosion in neutral or slightly acid chloride solutions around the edges of two surfaces in contact. Coating with a material such as petrolatum before assembly can practically eliminate crevice corrosion in bolted, riveted or spot welded assemblies. In sea water there is much opportunity for crevice corrosion at barnacles.

Pitting corrosion itself may be minimized by appropriate steel composition and by increasing the supply of oxygen. Type 316 steel is very resistant to pitting; resistance to pitting of any stainless steel is improved by increasing the velocity of liquid flow to above 5 ft. per sec. with as much aeration as practicable.

Galvanic corrosion becomes of significance only when stainless is deprived of its protective film, as in reducing media or in chloride solutions such as sea water.

Stress-corrosion, analogous to season cracking of brass, has been observed. Its occurrence is fortunately small, relative to the thousands of successful similar applications. Stress, either externally applied or residual (internal), can cause cracking in certain corrosive environments. Liquids containing halide ions are the worst offenders, and it may well be that a pit – possibly of microscopic dimensions – is the nucleus of a notch which extends into a crack under the influence of an appropriate stress and causes failure.

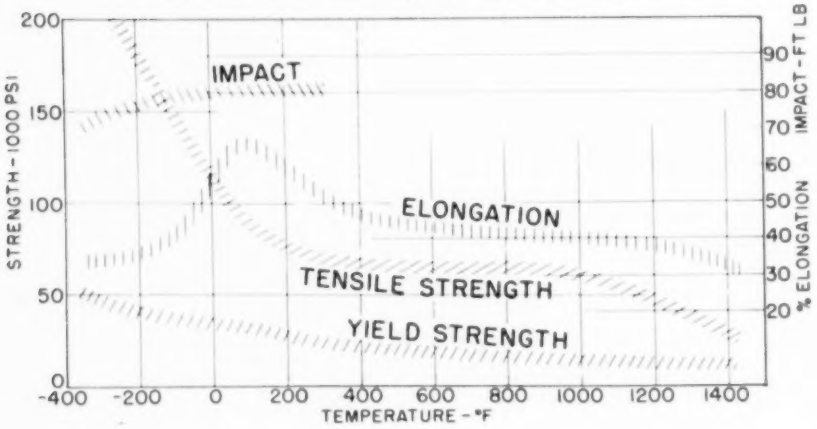
True stress-corrosion cracking (including corrosion-fatigue cracking) is characteristically transgranular, in contrast to intergranular corrosion whether or not aggravated by stress. Strangely enough several 18-8 coffee urns have failed – here at least is striking evidence of the plight of connoisseurs who put up with horrible perpetrations in the name of coffee.

J. J. Heger, in a comprehensive lecture at the Metal Congress in 1949, listed certain conditions that have been found to reduce the incidence of stress-corrosion in stainless steels or to prevent it:

1. *Design* which minimizes fluctuating thermal or mechanical stresses.

2. *Composition* – The molybdenum-bearing Types 316 and 317 increase resistance to film penetration; the low-expansion Types 410 (12% Cr) and 430 (17% Cr) are relatively immune.

Fig. 8 – 18-8 Austenitic Stainless Is Ductile and Tough From Liquid Nitrogen to Visible Heat. Sharp rise in strength below zero is due to formation of martensite during cold work stretching of the tensile specimen



Preventing Intergranular Corrosion

3. *Heat Treatment* – Final stress-relief annealing at 1500 to 1700° F., followed by air or furnace cooling, confers immunity to stress-corrosion. This is only applicable to 18-10 Ti (Type 321), 18-11 Cb (Type 347) and 18-11 Cb-Ta (Type 347 A) in which the carbon is fixed, or to the ultra low-carbon austenitic Types 304 L and 316 L, if service is to be in corrosive surroundings. Other types will become susceptible to intergranular corrosion.

4. *Mechanical treatment*, introducing compressive surface stresses by honing, peening or shot-blasting improves the material, whereas tensile surface stresses induced by grinding or polishing damage it.

5. *Chemical Treatment* – Cathodic protection, and inhibitors such as chromates and phosphates, are effective retarding agents. Pickled surfaces are more resistant than polished surfaces.

Intergranular corrosion, one of the few serious ailments of austenitic stainless steels, has been studied very extensively, mainly because its diagnosis has required a thorough understanding of the mechanism, and its cure has resulted from the correct diagnosis. It is a most fascinating example of the profound effect of reaction and diffusion rates.

Intergranular corrosion, although rarely found in ferritic or martensitic stainless steels, is well recognized not only in the austenitic types but also in ordinary steel (caustic embrittlement) and in nonferrous alloys such as the duralumin type. It is insidious, for the surface may appear essentially unchanged while the strength and ductility are sharply reduced; the metal becomes "dead"; it loses its metallic ring. Another insidious feature is that, whenever the metal is in a susceptible condition, attack may occur even in environments to which the normal alloy is absolutely immune, such as in dilute sulphuric acid containing ferric or copper sulphates.

Intergranular corrosion *never* occurs *unless* the metal has been improperly heat treated. All of the austenitic stainless steels are potentially susceptible, and the degree of sensitization increases with carbon content and period of exposure between 900 and 1500° F. It is caused by a severe depletion of chromium in the metal close to the grain boundaries in which carbides containing up to 90% chromium have precipitated. However, if the time at temperature is sufficiently long, chromium will diffuse into the depleted zone from the ample reservoir within the grain; corrosion resistance is recovered, but – except for cold worked metal – a long time is required.

There are three available practical methods for prevention:

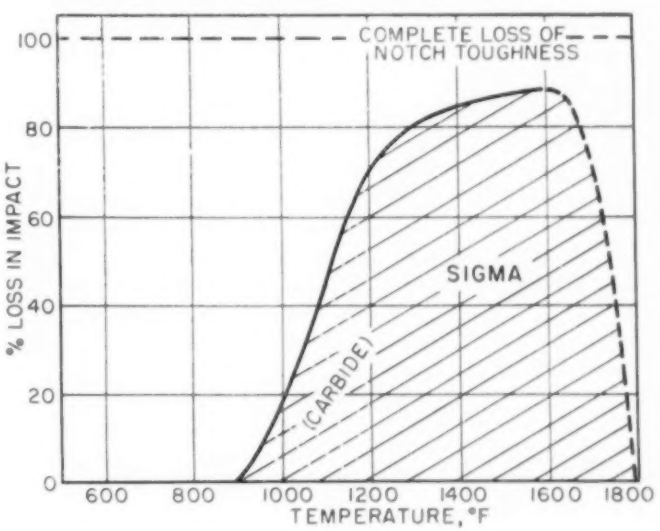
1. The addition of a stronger carbide-forming element (titanium or columbium) to form an inert carbide.

2. Spreading the precipitated chromium carbide throughout the grain, on slip bands produced by prior cold work, thereby narrowing the depleted zone so much that recovery is achieved by a short heating at about 1350° F.

3. Reducing the carbon so low that none precipitates during welding and other fabrication operations – the ultra low-carbon Types 304 L and 316 L.

Oxidation or Scaling – The protective film or passivity which makes stainless steels so inert in oxidizing environments at ordinary temperatures is manifested in similar environments at elevated temperatures by the formation of a thin scale, relatively impermeable to oxygen. Here again, chromium is the effective agent, but because oxygen gradually diffuses through the scale and because chromium oxidizes preferentially to iron, the metal adjacent to the scale becomes depleted in chromium, and the remaining iron oxidizes into a more

Fig. 9 – Precipitation of Network of Brittle Phase (Sigma, Chi, or Carbide) During 3000 to 10,000 Hr. Between 1000 and 1800° F. Badly Embrittles Austenitic 18-8's Containing Molybdenum. (Smith, Dulis and Houston, ASTM *Transactions, Vol. 42 and 45)*



porous type of scale. This gradual breakdown in resistance to scaling is a function of chromium content, temperature, and time at temperature as shown in Fig. 7. Accordingly, one can place maximum temperature limits for continuous use in air without undue scaling and these are given in most handbooks, but they are usually conservative values. Even at 2200° F. (200° above the recommended maximum service temperature in air) the rate of scaling of 27% chromium steel is only about 1% that of a plain carbon steel.

Experience shows that any element added to iron can enhance resistance to scaling only if that element oxidizes more readily than iron. Thus the addition of silicon or aluminum greatly improves the resistance to scaling, which accounts for Types 302 B (18-9 with 2% silicon), 314 (25-20 with 2% silicon) and 406 (12% chromium with 4% aluminum).

Recently a peculiar type of oxidation known as catastrophic has arisen to plague a few users of stainless steels. Though incompletely understood, it appears that the vapor of certain low-melting substances (among them molybdenum oxide, from selective oxidation of molybdenum-bearing grades, and vanadium oxide, found in the ash of certain fuels) can accelerate the rate of oxidation enormously when the oxygen supply is severely restricted, as in recesses or on contact surfaces. Circulation of air across all surfaces is an effective preventive for catastrophic oxidation.

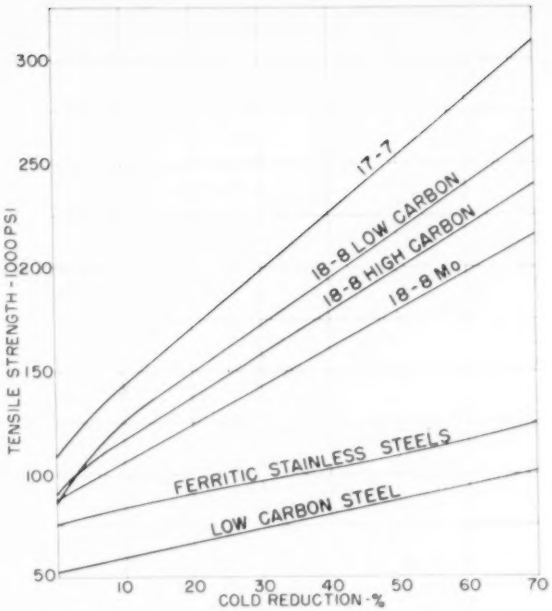


Fig. 10 – Metastable Austenitic Stainless Steels Can Be Strengthened Remarkably by Cold Work. (Modified from Rustless Iron & Steel Corp. diagram)

MECHANICAL PROPERTIES

Turning now to mechanical properties, both chromium and nickel stiffen iron. The high-chromium ferritic steels have low notch toughness at ordinary temperatures but improve greatly above 200 to 300° F. In tempering the martensitic grades, the 900 to 1100° F. range should be avoided, else both toughness and corrosion resistance are lowered. The cutlery grades are tempered only to relieve stresses (300 to 600° F.). The austenitic group are outstanding for ductility and toughness over their whole range of application, as illustrated in Fig. 8. Addition of molybdenum or columbium to 18-8 enhances creep and rupture strength at elevated temperatures so those types are used in gas turbines and jet engines. However, structural changes have been observed during exposures of from 4 to 14 months, and the severity increases with temperature – at least up to 1500° F., the limit of our measurements, where only 5% of sigma (or chi) and carbide in a network cuts the toughness down to one-eighth of its original value. See Fig. 9. It is likely that complete recovery can be obtained by reannealing above 1700° F. Regular 18-8 seems almost immune to sigma formation, but almost any addition (including higher chromium and nickel) makes the alloy susceptible. However, to date, only the austenitic grades containing molybdenum have been much affected as to their mechanical properties.

Strengthening by cold work with minimum loss of ductility is another unique property of some stainless steels. This capacity is highly dependent on composition, as shown in Fig. 10; the optimum composition is about 17% chromium, 7% nickel (Type 301). This is one of the most unstable low-carbon austenites at room temperature, so it strengthens very rapidly by martensitic transformation induced by cold work, thus providing high strength with generous ductility. The line for mild steel is well below the plain chromium stainless steel curve, but it work hardens similarly.

The 17-7 composition is, however, not the best for all types of cold forming. Though 17-7 is best for high strength, 18-9 is best for deep drawing where maximum uniform elongation

is required, and 17-11 is superior for spinning where minimum rate of work hardening and low yield strength are needed.

SELECTION FOR SPECIFIC APPLICATIONS

It is estimated that some 15,000 industrial plants in America are now using stainless steel either in their final product or to produce that product, so any mention of specific applications must necessarily be limited to the larger uses.

At the outset it should be noted that the recent nickel shortage has frequently forced civilian users to try new or unfamiliar grades, sometimes with conspicuous success.

In the automotive field, stainless steel is used primarily for car trim, radiator grills, hub caps and exhaust valves, with some recent models using more than 60 stainless parts. It is fortunate that the ferritic 17% chromium Type 430 has long been the most popular for the principal items, as it is nickel-free.

In the aircraft field, jet engines are actually using four times as much of the A.I.S.I. standard stainless steels as "superalloy"; such parts as engine enclosures, combustion chambers and tail pipes are using Types 347 A, 321 and 310. In piston engines, exhaust manifolds of Type 321 or 347 have long been standard and Type 410 is used for compressor blades, engine enclosures and fireproof bulkheads.

In light-weight rail and truck transportation

A Few of Many Uses

the cold worked, high-tensile Type 301 steel has enjoyed a unique popularity because of its high strength-weight ratio combined with its attractive appearance and ease of fabrication and maintenance. The original "Denver Zephyr", now nearly 20 years old, is still giving excellent service on another run on the Burlington railroad.

Architects began to use 18-9 (Type 302) for exterior and Type 430 for interior decorative purposes almost a generation ago and time has confirmed the choice. Stainless "curtain-wall construction" with Type 430 is the newest development in this field. This steel was never considered suitable for urban or industrial exteriors until the nickel scarcity forced its trial in several notable installations such as Pittsburgh's new Gateway Buildings (see Fig. 12). As siding and roofing for industrial buildings it can compete successfully with galvanized sheet if the expected life is beyond 15 years.

In food processing, Type 304 is the standard grade. Type 316 is used to handle stronger food acids encountered in processing tomatoes and pineapples. With nickel rationed, Type 430 has come into use for processing neutral foods.

In the brewing industry, stainless steel is generally established as a preferred material, particularly because of its ability to be thoroughly cleaned. (Wild yeast has crippled breweries for months at a time.) Stainless steel is also standard equipment in the processing of the most important cola drinks. One of the newest large-scale uses of Type 302 is for handling of milk on the farm, from milking machines through pipes to refrigerated portable tanks.

In chemical industries, the ultra low-carbon 304 L and 316 L are now replacing regular 304 and 316 types and substituting for the corresponding rationed columbium-bearing steels in service up to 800° F. 316 L offers greater resistance to intergranular corrosion than is afforded by 316, and 304 L is equivalent to Type 347 A in permitting welding and hot forming without sacrificing corrosion resistance, as shown in Fig. 11. One important reason for rationing of nickel to commercial users is the extensive demand for these grades by the Atomic Energy Commission in its chemical processing equipment.

Fig. 11 — Resistance of Extra-Low-Carbon 19-10 Type 304 L and 18-11 Cb Ta Type 347 A to Nitric Acid After Heating at 1250° F. Two hours at 1250° is a sensitive indicator of possible damage during welding or during hot fabrication. (Buck, Heger, Phillips and Queneau)

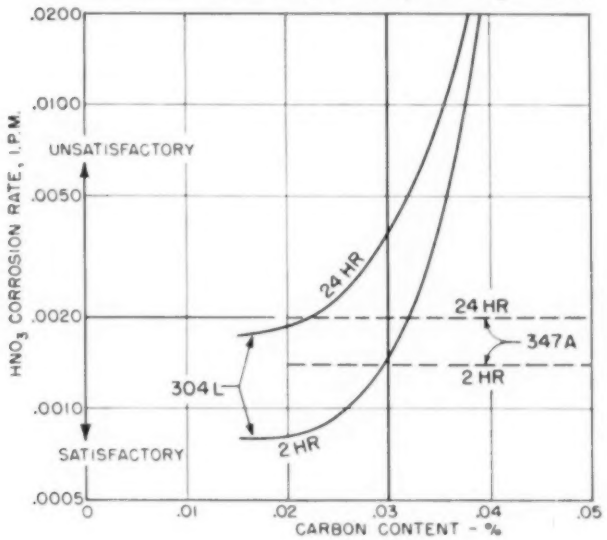


Fig. 12 — Curtain Walls in Pittsburgh's Gateway Buildings (Exterior Unit Panels, Story Height, Inclusive of Window Frames) of Plain Chromium Steel Sheet are Architecturally Beautiful, Permanently Durable, and Economical in Erection

In petroleum refining Type 410 continues to be a popular material for lining reaction chambers, whereas for cracking-still tubes both regular and modified 18-8 are rather widely used.

The textile industry uses much stainless in dyeing and bleaching, especially Types 304 and 316. Stainless steel, unlike most other materials, generally does not absorb or react with dyes, thus insuring bright and uniform colors.

In power plants, the special 12% chromium grade (Type 403) has been standard for turbine blading for many years, and Type 347 A has been put into some of the newest steam lines for the highest temperatures and pressures. In the generation of nuclear power, austenitic stainless steels appear destined to play a leading part because of their high resistance to corrosion by liquid heat exchangers.* Stainless steel piping required for the fuel containers, the circulating liquid (sodium), and the heat-exchanger of one reactor is estimated at 10% of the $50,000,000 plant to generate 150,000 kw.

For domestic uses Type 302 is the standard grade except for cutlery, of which the 12% chromium (Type 420) grade is used for the medium quality and the 17% chromium (Type 440) grade for the highest quality. Stainless has been adopted widely in medical circles because it is so readily cleansed and sterilized and is inert to all substances encountered.

Recently the steelmaker was confronted with a sudden request for a steel with the same thermal expansion as the glass of television screens at temperatures as high as 2250° F. This challenge was promptly met with a new stainless steel known as "17 TV"; hundreds of thousands of television tubes were made with high success. Now it has been largely replaced by carbon steel and a new ceramic gas-tight bond. You may again be using stainless steel for color television which appears to impose much more severe requirements on the tube.

*For a comprehensive study of atomic power plants and their metallurgy, see *Metal Progress*, August 1953, p. 97.

NEW DEVELOPMENTS

Nickel Substitutes — Rationing of nickel has intensified the search for other austenite formers, particularly for high-tensile steels for lightweight construction. One containing 17% Cr, 6% Mn, and 4% Ni proved very acceptable to both producer and user as a substitute for Type 301. More recently, with the nickel limit lowered to 1%, higher manganese and nitrogen levels were explored, and a 16% Cr, 17% Mn, 1% Ni, 0.15% N steel has been developed and marketed. Its mechanical properties and response to cold work resemble a more stable austenite similar to Type 304, and it thus has less ductility for a given strength. It is also very difficult to make because of the accurate composition balance necessary to obtain a commercially hot workable product with the users' limit of 0.10% carbon. So far it has been expensive and lacks manufacturing consistency.

The vastly increased use of Type 430 as a substitute for Types 302 and 304 has met with success in many applications and with difficulties in others.

Precipitation Hardening — Ever since stainless steels have been widely adopted for applications calling for high strength and corrosion resistance, metallurgists have searched for alloys combining these two properties (without being limited to thin sections, heavily cold worked). Precipitation hardening types of stainless steel have now become practical realities in two structural varieties: *(a)* martensitic as furnished, and *(b)* austenitic as furnished.

In the first, the austenitic structure formed on heating is so unstable that it transforms to martensite during cooling, and this martensite can be further hardened to about C-45 by tempering. One steel of this type contains about 17% Cr, 7% Ni, 0.7% Ti and low carbon. It is welcome to engineers for its nonseizing properties in contact with softer stainless. Wind tunnels for the National Advisory Committee for Aeronautics are made of it, for its unique

combination of high proportional limit with high corrosion resistance in thick sections.

In the second type, the austenite is sufficiently stable to remain largely intact on cooling to room temperature, thus facilitating cold forming. Severe cold working, or reheating to low austenitizing temperatures and cooling, transforms the structure to martensite, and subsequent tempering hardens the metal further. A representative composition is about 17% Cr, 7% Ni and 1% Al with low carbon. An interesting use is for spring wire. It has prospective use in airframes because its strength-to-weight ratio is better than titanium and the cost is much lower. Steelmakers will have to surmount the delicate composition balance now required in the current compositions.

A third variety is anticipated, in which marked precipitation hardening occurs in an alloy which remains substantially austenitic. One such steel containing about 0.4% C, 10% Cr, 21% Ni, 4% Mn and 4% Al has been reported.

The Future for Stainless

Extrusion – As the alloy content of stainless steels increases, they become increasingly hard to hot work and more susceptible to hot cracking under tension. A new and very promising approach to this problem is the use of compressive hot working by extrusion with a fiberglass lubricant. Tubing is now in commercial production and shapes are in prospect.

Various fads have had their run in stainless steels as in other facets of civilization. Some 15 years ago the addition of a minute amount of silver was claimed to obviate pitting and crevice corrosion, but that bubble soon burst. Later the surface coloring of stainless attained some popularity, and recently a coating called "Liquid Stainless" (flakes of 18-8 in a lacquer) was offered as a stainless veneer for any object. Such fads come and go while stainless steels themselves go on serenely because of their unique and economical qualities.

Book Review

The Commercial Metals (Other Than Iron)

"Modern Uses of Nonferrous Metals", Second Edition, 1953. Edited by C. H. Mathewson. American Institute of Mining and Metallurgical Engineers, 29 West 39th Street, New York City. Price $7.00 ($4.00 to members of A.I.M.E.).

Reviewed by CARL E. SWARTZ*

DURING the last 15 years most supervising metallurgists have been faced with the problem of recruiting additional personnel for the technical work at hand. This has been attacked in a number of ways with varying results. Since the trained and experienced persons ready for technical assignments have not been generally available, sometimes the bright young high school graduate or promising young man in a labor gang has been brought into the department. After a few days of helping on a furnace, rolling mill or collecting samples for laboratory evaluation, he has come to toy with the idea of becoming a "metallurgist". At this point he may ask the supervisor how he can reach this goal. In addition to inquiring about courses in the local night school he may ask for recommendations for spare-time reading.

"Modern Uses of Nonferrous Metals", in its second edition, can well be placed near the top of such a reading list. If our young man reads this book diligently, asks questions, follows up the references suggested and implied, he can have a wealth of valuable general information about metals and some interesting and helpful details about the particular metals with which he is working. He can also acquire some insight into the work of the metallurgist, his viewpoint, and his problems.

Not only will this book serve as background for the neophyte, but it will help the trained metallurgist and other mature workers in the metal industry. Since the text is well written, it can be read in the same manner as the weekly news magazine or the general magazine – as a timely, factual, and fascinating series of articles. It also has permanent value on the reference shelf where it will be handy to supply information in the less familiar parts of the metal field.

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In reading the various chapters, this reviewer is impressed by the changes that have taken place in applications of the metals. Sometimes large changes are caused by the use of small amounts of other elements – for example, the chapters on magnesium and nickel show how a little of these elements added to molten iron of proper purity causes the graphite to precipitate in nodular form rather than as flakes, with a corresponding increase in strength and ductility. Again, Jeffries' article in the first edition (1947) is quoted in the chapter on tungsten, as follows:

"It is an amazing fact that one minor metal, tungsten, has played the dominant role in three great industrial advances since the beginning of this century. The first was high speed steel. Iron was the basis of the alloy but tungsten was the main alloying element. The important contributions of chromium and vanadium to the improved qualities is a splendid example of the value of multiple alloying. Molybdenum can be substituted for part or all of the tungsten, a fact that was taken advantage of during World War II to conserve the tungsten. This possible substitution also makes it certain that the valuable properties of high speed steel will be available for a very long time. A prominent mechanical engineer estimated that high speed steel made possible the production in five days that otherwise would have required six. This significant contribution was achieved with the consumption of only about $50,000,000 worth of alloy annually.

"The second advance began in 1904 with the substitution of tungsten for carbon in lamp filaments. By the middle of the 1920's it would have cost the people of the United States $2,900,000,000 per year extra to have the same amount of light with carbon filament lamps, yet the annual cost of tungsten to do this was only of the order of $100,000. This saving in cost of light effected by the use of one pound of tungsten was around $300,000!

"The third of these great advances was cemented tungsten carbide. Here cobalt or its equivalent in minor quantities was a necessary partner. Within the next 10 years it will make possible an increase in production over high speed steel as great as the latter did over its predecessors. Furthermore, it should do this by using not more than $10,000,000 worth of tungsten per year. Small amounts of titanium, tantalum or columbium carbides greatly improve the cemented tungsten carbide, especially for steel turning. This is another example of the value of multiple alloying elements and the great economic value of minor elements."

Although the term "nonferrous" in the title implies that the treatment is slanted in this direction, those primarily interested in iron and steel will find much worth-while reading in the various chapters on chromium, cobalt, molybdenum, nickel, tungsten, and vanadium – as well as in the chapter on selenium and tellurium. In fact, in its next edition this book might be enlarged to include short chapters on iron and steel and alloy steels. Then it could serve as a general, if short, treatise on metals and their uses, further helping to erase the artificial demarcation between iron and steel and all other metals.

The editor, Professor Mathewson, has rightly left the description of each metal to the judgment of the individual author, thus sacrificing some desirable order and uniformity of content, chapter to chapter, for the freedom which allows the expert to select the best form of presentation. And these authors are experts, as a glance at the table of contents will prove.

At the risk of inviting a growth paralleling that of the Metals Handbook, one might wish for some additional detail in some of the discussions, and some additional material not presented. For example, the metal cadmium received substantially less attention in this second edition than in the first edition although the tonnage consumed has increased considerably since 1935. Such topics as the use of cadmium in silver brazing alloys and in special soldering techniques required in soldering sheet zinc and galvanized sheet would be of interest; the use of cadmium in nuclear reactors is also important. Although purposely omitted, a chapter on miscellaneous metals and elements such as the rare earths, boron, lithium, calcium, might be valuable to many readers.

While the current volume is called a second edition, it is a complete revision containing more than 100 additional pages. The arrangement is the same as before, with the various metals discussed by separate authors in separate chapters. Many of the chapters have been expanded and new chapters have been added, such as that on titanium and zirconium. Complicated technical terminology has been generally avoided – where unavoidable, the terms are adequately explained. So the discussion is easily understood even by those not familiar with the fields covered, but at the same time it is written in an interesting manner and in technically correct detail, so it can serve as a general reference handbook.

My own use of this book is not infrequent.

Advertisement

ELECTROMET Data Sheet

A Digest of the Production, Properties, and Uses of Steels and Other Metals

Published by Electro Metallurgical Company, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. • In Canada: Electro Metallurgical Company, Division of Union Carbide Canada Limited, Welland, Ontario

Why 3 Per Cent Chrome Steel Makes Good Castings for Wear Resistance

Castings of 3 per cent chromium steel have been used in substantial tonnages, for many years, for various equipment parts demanding good wear resistance. Such castings offer an excellent combination of hardness and toughness. Typical applications are crusher parts used in rock- and ore-crushing equipment, swing hammers for pulverizing coal, railroad switch frogs, gears, pulleys, sheaves, and other castings that must meet severe conditions of wear.

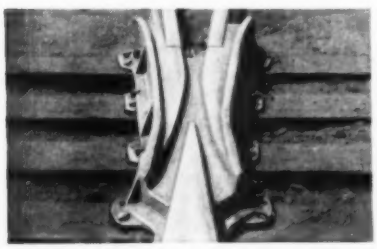

Fig. 1. Railroad switch frogs, which are subject to severe wear, give outstanding service when cast of 3 per cent chromium steel.

The 3 per cent chromium steels, are normally produced in a carbon range of 0.30 to 0.50 per cent. They exhibit excellent depth-hardening properties, which simplify heat-treatment and insure uniformity throughout heavy sections. The analysis is usually modified by a molybdenum addition, since this element aids in increasing hardenability.

Fig. 2. Grating for top of shake-out machine is cast of 3 per cent chromium steel to give good wear resistance and long life.

Properties Improved by Heat-Treatment

The best properties of 3 per cent chromium steels are developed through heat treatment. Generally, this consists of a normalizing treatment from 1650 deg. F., followed by tempering in a range between 1000 and 1250 deg. F., depending on the physical properties desired. Double normalizing is sometimes used to obtain further improvement in the grain structure. With carbon on the high side of the specification, air-quenched castings show a Brinell hardness number of over 400 in 3-inch sections. This hardness is practically uniform throughout the section. Oil quenching is employed to produce higher hardness and depth of penetration, and even in a 4-inch section, a hardness number of over 500 Brinell is obtained.

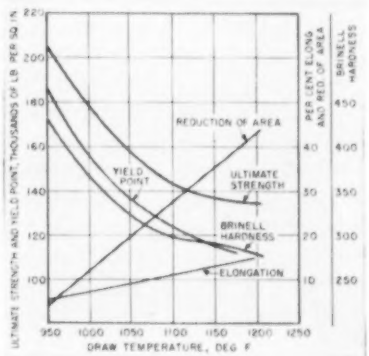

Fig. 3. These curves show the response to tempering of a 0.37 per cent carbon, 2.93 per cent chromium, 0.35 per cent molybdenum steel previously normalized from 1650 deg. F.

The steel also shows good response to tempering. After a normalize and a 1100 deg. F. treatment, it has a tensile strength close to 150,000 pounds per square inch, with an elongation value of about 12 per cent, and a Brinell hardness of about 300. When greater ductility is required, tempering should be done at higher temperatures. However, in such instances, some strength and hardness are sacrificed.

Fig. 4. Photomicrograph of 3 per cent chromium steel normalized from 1650 deg. F. and tempered at 100 deg. F. (X250). The pseudo martensitic structure is well suited to resist abrasion.

Effect of Other Alloy Additions

Molybdenum in the range from 0.30 to 0.50 per cent will improve depth-hardening characteristics and aid in reducing susceptibility to temper brittleness in the lower temperature ranges. If the molybdenum-bearing steel contains relatively high carbon (0.40 to 0.60 per cent) additions of approximately 0.08 to 0.10 per cent vanadium provide greater uniformity in hardening. Small additions of silicon increase strength and hardness and this element is sometimes increased to 0.80 or 1.00 per cent. Manganese is added in amounts between 0.50 and 0.80 per cent.

Metallurgical Service Available

When you have occasion to produce castings for applications involving severe abrasion and wear, it will pay you to investigate the advantages of using 3 per cent chromium steel. If you need help on some specific metallurgical problem, be sure to consult one of ELECTROMET's specially trained metallurgists and engineers. For further information, write to the nearest ELECTROMET office: in Birmingham, Chicago, Cleveland, Detroit, Los Angeles, New York, Pittsburgh, or San Francisco. In Canada: Welland, Ontario.

The term "Electromet" is a registered trademark of Union Carbide and Carbon Corporation.

Correspondence

Paul Richard Kuehnrich
English Toolsteel Metallurgist

SHEFFIELD, ENGLAND

In the last paragraph on page 99 of the February issue, Burns George (in describing the historical development of toolsteel) unfortunately misquoted the name of an eminent British metallurgist.

High-carbon, high-chromium toolsteels, as we know them today, had their origin in the "wortle-plate" compositions used for many years in the cold drawing of wire. Paul Richard Kuehnrich, a naturalized Englishman of German birth, pioneered their development as toolsteels while head of the Sheffield steel firm of Darwins Limited. The prototype he introduced was "Neor" brand with 2% carbon plus 12 to 14% chromium. This steel is still a firm favorite for many applications in the English and Continental markets.

Paul Richard Kuehnrich

Later he reduced the carbon to 1.5% and added a small amount of molybdenum and cobalt, making a strongly air hardening steel possessing negligible distortion characteristics. This he called "PRK-135". It was used for many years in razor blades of the wafer type and is still sold as a toolsteel under the brand "Cobaltcrom". Incidentally, Paul Richard Kuehnrich was one of the first metallurgists to explore the possibilities of cobalt as an alloying element in steel.

Finally he launched an ambitious project for the manufacture of cutlery, spoons and forks, under the name of "Chrysteel". This employed a modification of "PRK-135" with approximately 1% carbon. I still possess a set of this cutlery which retains its original brilliant stainless luster, free from scratches, and its keen cutting edge. Unfortunately this venture led to financial difficulties and caused his premature death in tragic circumstances in 1932.

Nevertheless, Paul Richard Kuehnrich was a man of stature – in both senses of the word. His long white beard added to his individuality as a manufacturer of razor blades! He was also a pioneer in improving working conditions in factories. In the late 1920's he employed a large number of female operatives, and for their benefit he decorated the factory walls with trellis work on which were growing sweet peas and other climbing plants, in company with hanging baskets of scarlet geraniums.

ALAN TORRY
Technical Director
Darwins Limited

"Aircraft Quality"

CANTON, OHIO

We were quite interested in the second portion of the McFarland lecture on toolsteels by Burns George, as published in *Metal Progress* for March. There is one statement that we believe needs correction. It comes under the sub-heading of "Improving Quality by Inspection" on page 77, and states: "The Magnaflux system of inspection provides an almost perfect check for the presence of seams or surface cracks and this was first used in the toolsteel industry. When this inspection is applied to constructional alloy steels, the product is referred to as 'aircraft quality' and you are charged extra."

We would like to point out that in constructional alloy steels the assignment of the aircraft quality extra refers primarily to the internal quality of the steel, especially the amount and length of allowable Magnaflux indications. It also relates to certain other metallurgical features normally considered restrictive if applied to regular alloy quality. However, it does not involve testing for ***surface*** imperfections by magnetic particle methods, and, in fact, it has long been required that ample metal be removed from bars prior to the Magnaflux test.

A. F. SPRANKLE
Metallurgical Engineer
Steel & Tube Division
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Personal Mention

A. H. d'Arcambal

L. S. Fletcher

ALEXANDER H. D'ARCAMBAL, past president (1932), was recently elected president of Niles-Bement-Pond Co., West Hartford, Conn. Mr. d'Arcambal has been with the company 35 years, starting as a metallurgist in the Pratt & Whitney Division. In 1927, he was appointed sales manager of the cutting tool and gage division and in 1941 was elected vice-president. He was named general sales manager, director, and consulting metallurgist of the company in 1950. Mr. d'Arcambal was born in Kalamazoo, Mich., and graduated from the University of Michigan in 1912 with the degree of bachelor of chemical engineering. For two years before joining Pratt & Whitney in 1919, he was with Wright-Martin Aircraft Corp. as chief metallurgist. In 1941 Mr. d'Arcambal was cited for outstanding achievement in chemical engineering at an engineering alumni conference of his alma mater. He is a member of the American Society of Tool Engineers (national president 1940-41), Society of Automotive Engineers, American Institute of Mining and Metallurgical Engineers, and the National Society for Quality Control. A biographical appreciation published in the June 1952 issue of *Metal Progress* gives further details of Mr. d'Arcambal's life and accomplishments.

LESLIE S. FLETCHER (Col. U.S.A., retired) has been appointed to the newly created position of Research Fund Director of the American Society of Tool Engineers, with the duty of cooperating closely with government, industry, and universities for advancing scientific knowledge in the field of tool engineering. Colonel Fletcher is a graduate of West Point Military Academy, and holds a B.S. degree in mechanical engineering from Massachusetts Institute of Technology. Assigned by the U. S. Army Ordnance Dept. to Rock Island Arsenal in 1932, he developed continuous manufacturing methods for metallic machine gun links, tank track parts, and stainless iron recoil cylinders. Later, at Frankford Arsenal, he was officer in charge of mechanical time fuse design and production. There he was active in the early work on steel cartridge cases and their heat treatment, and was a member of the Ordnance Department's ferrous and nonferrous metallurgical advisory boards. Immediately preceding World War II, he was officer in charge of Pitman-Dunn Laboratories at Frankford Arsenal. Assigned to field duty in 1942, Colonel Fletcher saw service in Africa, Italy, Europe and Japan, and received three decorations. Prior to his present assignment, Colonel Fletcher was technical director of Sam Tour & Co., consultants, of New York City. A member of the American Society for Metals since 1932, he is a member of the *Metal Progress* Editorial Advisory Committee, formerly served on the National Finance Committee, is a past chairman of the Tri-City Chapter, and held various offices in the Philadelphia and New York Chapters. He is also a member of the American Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers, Metal Science Club of New York and American Ordnance Association.

Ralph R. Ross, former tool development engineer in the manufacturing engineering department at Consolidated Vultee Aircraft Corp., San Diego, Calif., now holds the office of president of the newly organized firm of Expand-O-Matic, Inc., Reno, Nev.

Walter I. Weed has resigned as metallurgist in the research laboratories of the Armco Steel Corp., Baltimore, to accept a position as mill metallurgist for Rotary Electric Steel Co., Detroit.

Edwin A. Yeo, for sixteen years Cincinnati district manager for Leeds & Northrup Co., Philadelphia, has been transferred to Pittsburgh.

L. Dean Alspach, formerly of the Beryllium Corp., is now representing Penn Precision Products, Inc., Reading, Pa., in the Cleveland territory.

Ralph R. Nash, of the metallurgical engineering faculty at Rensselaer Polytechnic Institute, is conducting a double program of research for the Institute and the Rochester Ordnance District, Department of the Army. The purpose of the investigation is to obtain fundamental information on the plastic behavior of magnesium and magnesium alloys. Results of these studies will contribute to the continued development of improved high-strength magnesium alloys for ordnance and aircraft.

James P. Pettit, formerly chemical engineer for United States Defense Corp., St. Louis, is now manager of Precision Castings Corp., in the same city.

AGAIN REVERE SAYS:

"Copper is the metal of Invention!"

Few people would consider it possible to melt titanium at a temperature of 3140°F. or above in a mold made of copper, a metal which melts at 1980°F. Yet it is being done on a production basis, and is helping in the work of making titanium metal available on a commercial basis.

The secret lies in copper's high thermal conductivity. Molds made of Revere Copper by the Central Copper Works, Inc., Cincinnati, Ohio, have a Revere Copper baffle wrapped in a spiral around them. When installed in its jacket in the plant of Rem-Cru Titanium, Inc., Midland, Pa., the copper mold is connected to a source of high-velocity water. The high heat conductivity of the copper transfers heat so rapidly to the water spiraling along its surface that the copper never comes close to its melting point.

High heat conductivity is only one of the qualities that make copper "the metal of invention." Copper is also easily workable, has the highest electrical conductivity of any commercial metal, does not rust, is easily soldered or brazed, and can be welded perfectly. The Revere Technical Advisory Service will gladly collaborate on any special problems concerning the application and fabrication of copper. Just get in touch with the nearest Revere Sales Office.

Titanium ingot, 25" in diameter, 51" long, weighing 4,050 lbs., melted at 3140° F., and the water-cooled copper mold, which would melt at 1980°F. if it were not for copper's high heat conductivity. The flange on the mold is steel, welded to the copper by the inert gas shielded arc method, using silicon copper rod.

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Personals

Edward F. Hirsch has been appointed district manager for New York State and the New England territory for Alloy Metal Wire Co., Prospect Park, Pa., division of H. K. Porter Co., Inc.

Ray E. Slater, who for the past 15 years was foundry consultant for L. A. Cohn & Bros., Inc., Chicago, is now foundry consultant for Benj. Harris & Co., Chicago Heights, Ill.

P. F. Macherey, formerly metallurgist in the aircraft engine laboratory at the Studebaker Corp., South Bend, Ind., is now employed as a metallurgist with H. M. Harper Co., Morton Grove, Ill.

L. H. Yount has been transferred from the tank engine division of Chrysler Corp., New Orleans, where he served on the metallurgical staff, to the Guided Missile Branch of the Engineering Div., Chrysler Corp., Detroit, in the position of project engineer.

E. H. Mann has been appointed general sales manager of the Alloy Metal Wire Co., division of H. K. Porter Co., Inc., Prospect Park, Pa. Mr. Mann joined Alloy Metal Wire Co. in 1949 as a sales engineer in the Middle Atlantic district and in 1953 was promoted district manager to establish the New England office at Worcester, Mass. He is a graduate of Rensselaer Polytechnic Institute with a B.S. in metallurgical engineering, and prior to making his present connection was a metallurgical engineer in the chemical department of General Electric Co.

D. W. McDowell, Jr. has been released from active duty as commander with the U. S. Navy and has joined the stainless steel section of the development and research division of the International Nickel Co., New York.

John V. McCarthy, 1945 graduate of Massachusetts Institute of Technology, now covers the New England territory as salesman for the North American Smelting Co. of Wilmington, Del., and Vesuvius Crucible Co. of Pittsburgh.

Irwin William Evans, formerly employed by the Atomic Power Div. of Westinghouse Electric Corp., Pittsburgh, is now employed by the Morgan Engineering Co., Alliance, Ohio, as chief welding engineer.

Eugene H. Adams, who still retains his position as engineer with the Thor Corp., Chicago, has organized a business of his own, Ballistics Engineering Co. in Oak Park, Ill., which does custom gunsmithing of all kinds.

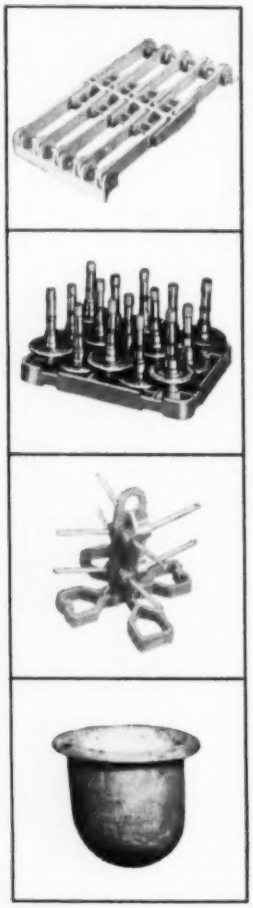
Howard Thacher Green, formerly with the Babcock & Wilcox Co., Alliance, Ohio, is now employed by the Cleveland Wire Works of the General Electric Co.

Edward A. Thomson has resigned as assistant chief metallurgist with Inland Steel Co., Chicago, to become assistant to the manager in the bar and strip and cold strip mills of Algoma Steel Co., Saute Ste. Marie, Ont.

James R. Elliott has been advanced to New England sales representative for C. I. Hayes, Inc., Providence, R. I. Prior to this he was connected with the service department for 12 years.

FAHRITE HEAT AND CORROSION Alloys holds up in HOT spots

The dipping basket and other heat-resistant castings shown are typical of the thousands produced by Ohio Steel for the heat-treating industry. From design to delivery, we adhere to buyer's specific requirements. There is no substitute for practical design, reliable metallurgy and ability to make a sound casting. Ohio Steel ranks high all the way. We would like to work with you on your requirements for heat-resistant castings.



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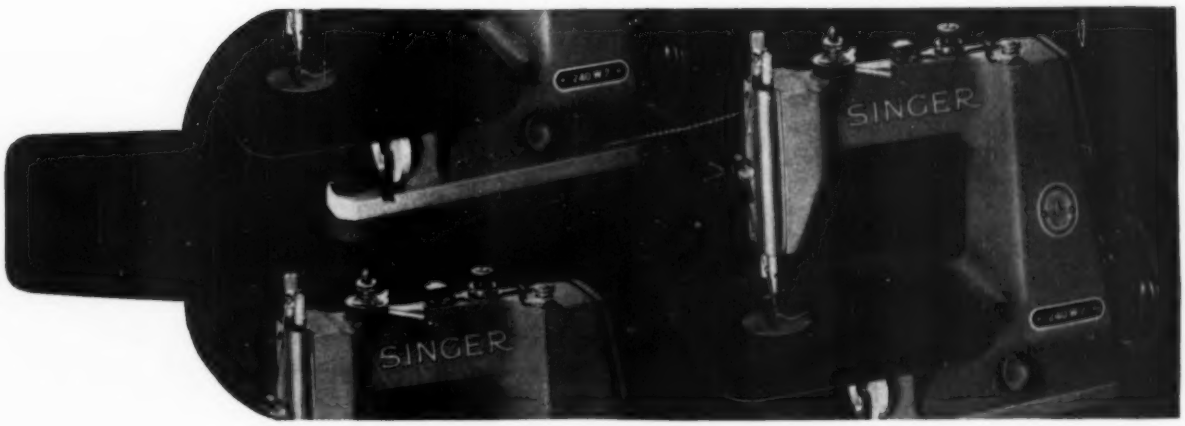

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"Better hardness, elimination of surface removal by cleaning, and the reduction of secondary operations have contributed to producing newer and better machines, which are operated at higher speeds with reduced wear. This has been made possible through the use of Armour ammonia in surface hardening processes."

Chief Metallurgist, Bridgeport Works,
The Singer Manufacturing Co.

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- ☐ "Investigation into the Carbonitriding of Plain Carbon Steel"
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P6

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Personals

W. J. Thomas, general manager of the tubular products division of the Babcock & Wilcox Co., New York, has been named a vice-president of the company. Mr. Thomas is a graduate of Carnegie Institute of Technology in 1922, and has been with Babcock & Wilcox since 1932.

G. D. Welty is now manager of the aircraft division of Aluminum Co. of America in Pittsburgh.

Thurston T. Paul has been transferred from his post as director of research, development and engineering at the Ordnance Corps' Watertown Arsenal and is now a student at the Armed Forces Staff College in Norfolk, Va. Colonel Paul expects an overseas assignment at conclusion of the course in midsummer.

Richard A. Burkett, formerly of the Beryllium Corp., is now representing Penn Precision Products, Inc., Reading, Pa., in Chicago.

John W. Kane has been transferred by the United States Steel Supply Co. from Pittsburgh, where he has been in charge of alloy steel, to Houston, Tex., to have charge of the sale of alloy, stainless, cold finished and toolsteel.

Charles H. Scharfe is now employed by the Navy Department, Bureau of Aeronautics, as aeronautical power plant development engineer in the Service Engines Branch, Power Plant Division.

John R. Witt is now on military leave of absence from the engineering department of Caterpillar Tractor Co., Peoria, Ill., having been called to active duty with the U. S. Army Reserve, Corps of Engineers.

Bruce W. Capek has been given a military leave of absence from Esso Standard Oil Co., Baton Rouge, La., to enter the Naval Officer Candidate Program. After a two-month indoctrination at Newport, R. I., he will be commissioned an ensign in the U. S. Naval Reserve.

Peter V. Schneider is now employed by International Business Machines Corp., Endicott, N. Y., as technical assistant in the sintered metal section of the metallurgical department. Prior to his new position, Mr. Schneider was technical adviser in the sintered metal division at Ford Motor Co., Dearborn, Mich.

D. H. Gardner, Detroit sales manager since 1946 for Sunbeam Corp., Industrial Furnace Div., Chicago, has been named division general manager. **L. W. Prestin,** former vice-president and division general manager, is now vice-president of Sunbeam's subsidiary at Toronto, Ont. **J. T. Williams,** metallurgical engineer and graduate of Purdue University, has been assigned to the Detroit area. **L. B. Canfield**, formerly in Chicago sales, has been assigned to the Philadelphia area as Sunbeam district sales engineer.

Julian D. Carey, Jr., formerly supervisor, metallurgical section, Construction Materials Laboratory of the General Electric Co., Bridgeport, Conn., has been transferred to the process engineering section, welding department of the company in York, Pa. He will be in charge of the metallurgical activities of the welding department.

Centrifugal casting of radiant tubes at Standard Alloy is a method backed by years of specialized alloy casting experience as well as machining, and welding operations.

During these years, hundreds of Standard Alloy radiant tube assemblies have been specified by furnace manufacturers, in new furnace equipment, and by furnace operators for replacement units.

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These uses are centered principally in applications where Zirconium's extremely high resistance to the attack of hydrochloric, phosphoric, certain mixed acids or the action of alkalies is essential. Other applications, including alloying, are becoming more numerous as the metal becomes in better supply.

Orders are being accepted for sheet, bars, wire, sponge, strip, briquette and tubing. By writing our New York City Office, you can obtain a brochure of properties and prices.

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SET-O-MATIC* DIAL GAUGE

Eliminates human error. Operator merely applies minor load and taps depressor bar. No setting of dial to zero.

OTHER FEATURES

- Major load applied under dash pot control
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Eliminates Operations... Increases Tests per Hour

All you have to do with the Model Y WILSON "ROCKWELL" Motorized Hardness Tester is apply the minor load and tap the major load depressor bar. The machine does everything else automatically. The cycle of Major Load operation may be less than 2 seconds.

This speed of test means great savings in time which will reduce your hardness testing costs. Yet it is done to Wilson's high standard of accuracy.

The utter simplicity of setting the SET-O-MATIC* dial gauge eliminates human error. The operator does not have to set the dial. The large pointer is automatically brought to "SET" position when the minor load is applied.

The Model Y Motorized WILSON "ROCKWELL" Hardness Tester is in production and orders are being accepted for early delivery. Write today for descriptive literature and prices.

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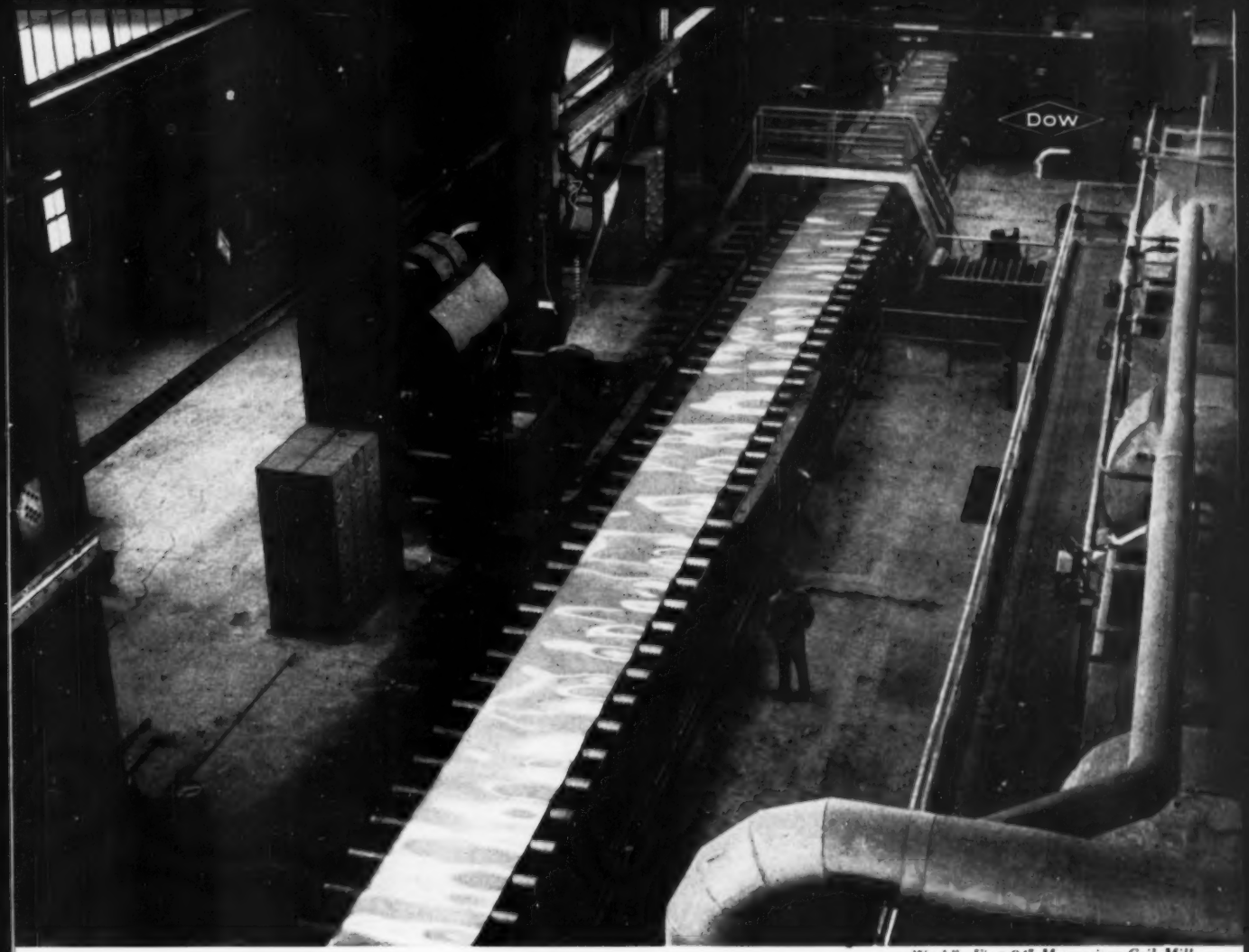
Personals

David B. Mazer and **Anthony Quaglia** are the new owners of the former Bennett Steel Treating Co., Newark, N. J. The name Bennett started in the heat treating industry in the year 1923, when **Wilbur R. Bennett** founded the Bennett Insured Steel Treating Co. It continued under that name until April 1938, when **Richard W. Thorne** took over the ownership of the company, under the name of the Bennett Steel Treating Co. The name has now been changed to Bennett Heat Treating Co., Inc.

J. S. Fullerton was recently appointed sales manager of Handy & Harman of Canada, Ltd., and is located at the principal office and plant in Toronto. Mr. Fullerton, vice-chairman of the Montreal Chapter and founder-president of the Canadian Welding Society, was formerly Eastern Canada sales representative and in charge of the company's Montreal sales office. **Donald W. Walker**, previously covering Western Canada and resident in Vancouver, has taken over the duties of the Montreal sales office.

Erwin F. Collins retired as head of the metallurgical engineering department of Bendix-Westinghouse Automotive Air Brake Co., Elyria, Ohio, on Jan. 15, 1954. Before joining Bendix-Westinghouse in 1946 "Doc" Collins held metallurgical positions with Continental Motors Corp., Packard Motor Car Co., Maxwell Motor Car Co., and Willys-Overland Motors, Inc. He was one of the first members of the Steel Treaters Research Society before it became the American Society for Metals. Mr. Collins is also a member of the Society of Automotive Engineers and the Ohio and National Society of Professional Engineers. After retirement he plans to play golf and experiment with medicinal herbs in Medford, Ore.

David Spear was elected a vice-president of Maremont Automotive Products, Inc., Chicago, at the annual meeting of the stockholders in March. Mr. Spear started as a metallurgist with Maremont in 1942 and in 1945 was placed in charge of the spring plant in Chicago. He was previously a metallurgist with Inland Steel Co., Chicago.



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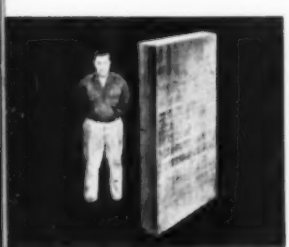
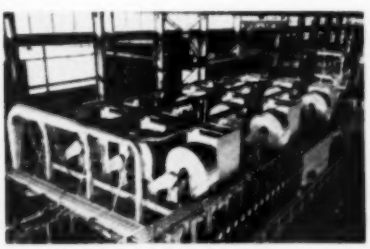
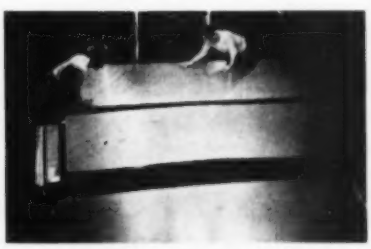
New Dow facilities—now in operation—are producing magnesium sheet in *quantity*. Wider, longer—magnesium sheet now offers a brand new challenge to designers, engineers, manufacturers. To cut costs, to save weight, to add strength—to do revolutionary new things for many products—get the new magnesium story! Call the nearest Dow sales office or write THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan.



Here for the first time, large magnesium rolling ingots weighing nearly a ton are being rolled.



Specially designed, carefully controlled ovens pre-heat huge magnesium ingots just before rolling.



Constant inspection plus rigid production controls assure uniform magnesium sheet quality.

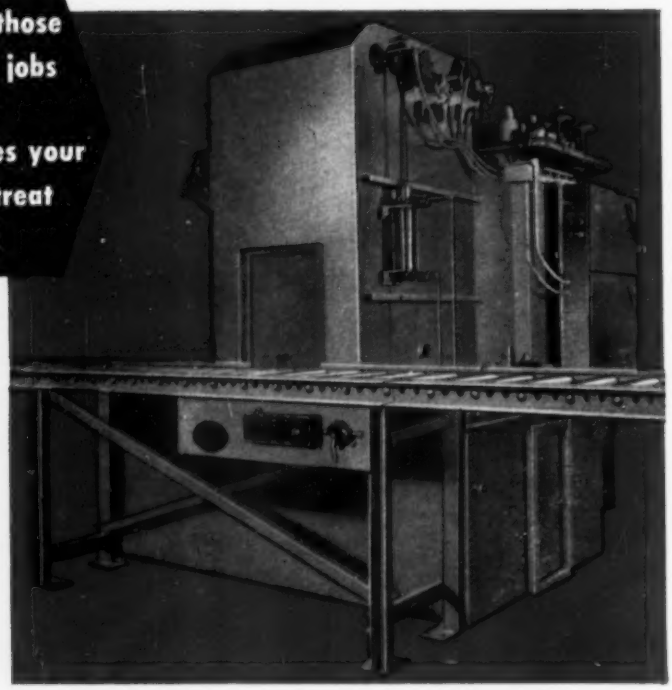
Note how coil of magnesium sheet illustrates new availability in greater widths and lengths.

you can depend on DOW MAGNESIUM

DOW

DOW FURNACE model "J"

Licks those tough jobs
●
Slashes your heat treat costs!



"NO-GAP" OPERATION—A batch type furnace with less than 30 seconds between loads. Work chamber is never exposed to air. Loading is accomplished while slow cooling or quenching a previous load.

GREATER PRODUCTION—The Dow Model "J" easily brings a 500 pound load from room temperature to 1500°F in less than an hour. Net capacity on light case work will range from 300 to 400 pounds per hour.

COMPACT CONSTRUCTION—Occupies floor area of only 7'10" x 14'4" giving maximum production for minimum floor space.

VERSATILITY—Ideal for carbonitriding, gas carburizing, clean hardening and carbon restoration. Hot oil quenching and atmosphere cooling equipment available.

EXCLUSIVE FEATURES—High capacity fan combined with heat capacitor assures uniform case depth throughout each load • Forced circulation of quench oil assures uniform hardness with minimum distortion • Sealed quench tank gives cleaner stock—minimizes fire hazard.

DOW FURNACE COMPANY

First WITH MECHANIZED, BATCH-TYPE, CONTROLLED ATMOSPHERE FURNACES

12045 Woodbine Ave., Detroit 28, Mich.
Phone: KEnwood 2-9100

Personals

Arthur A. Conrad, Jr., metallurgist, has joined the Detroit technical section of the development and research division of the International Nickel Co., Inc. A graduate in metallurgical engineering of Carnegie Institute of Technology, Mr. Conrad prior to his present appointment was chief metallurgist with Precision Metalsmiths, Inc., Cleveland. Previously he had been engaged in metallurgical work with Carnegie-Illinois Steel Corp., Pittsburgh and Duquesne, Pa., National Tube Co., Lorain, Ohio, and at United States Steel Corp.'s research laboratory, Kearny, N. J. He served with the U. S. Naval Reserve in 1942 to 1946.

Chester Shira has been added to the field staff of application engineers of the Lincoln Electric Co., Cleveland.

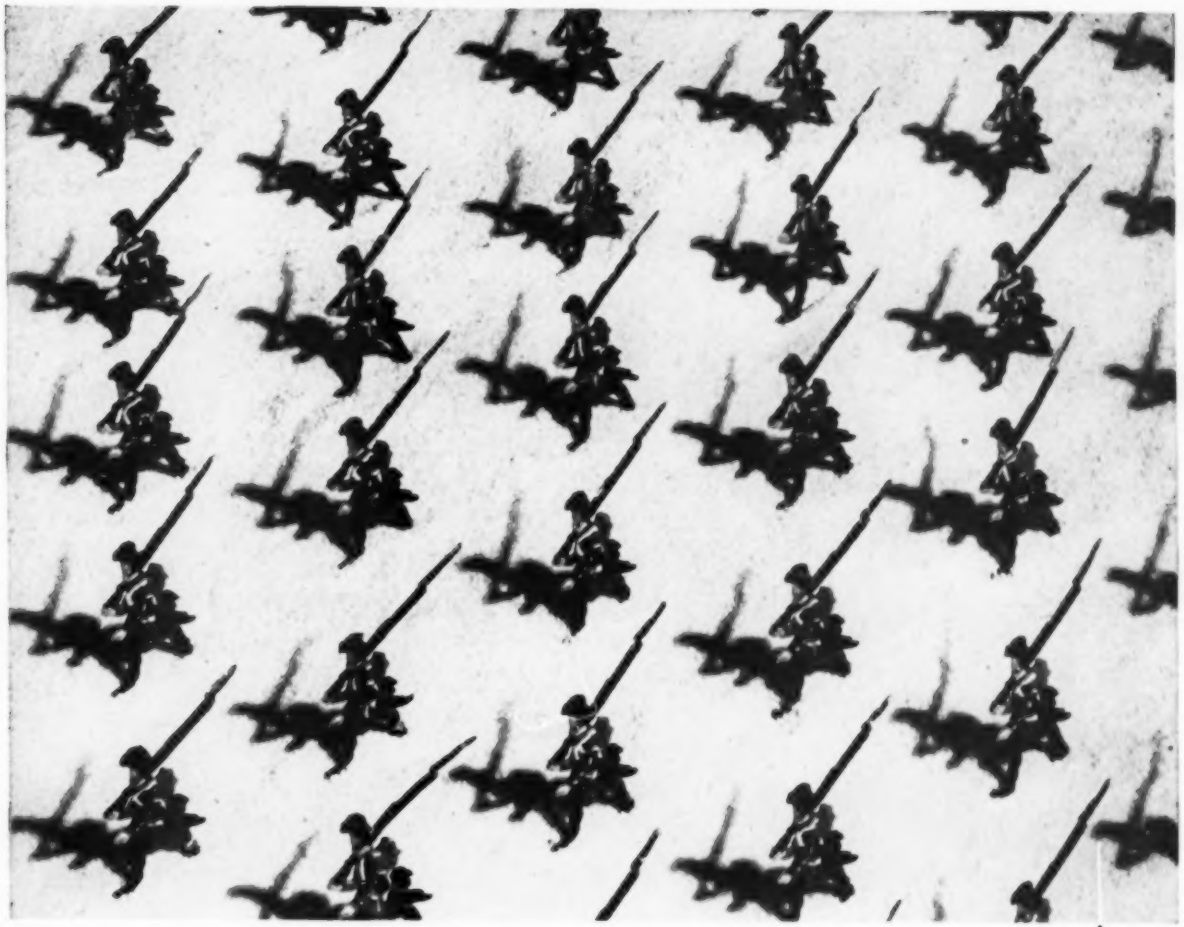
Rex E. De Long and **W. T. Williamson** have been appointed co-managers of the Pacific Machinery and Tool Steel Co., Portland.

Eric B. T. Kindquist has resigned as wire mill superintendent of the Eastwood Nealley Corp., Belleville, N. J., and is now vice-president of the Overlakes Corp., Garfield, N. J., and general manager of the Garfield Wire Div. of the company.

W. A. McIntyre has resigned as plant metallurgist in charge of the laboratory for Thompson Products, Ltd., St. Catharines, Ont., a position he had held for ten years, to become service engineer in Southwestern Ontario for E. F. Houghton & Co. of Canada, Ltd., Toronto.

Charles E. Paetschke, metallurgist with the E. I. du Pont de Nemours & Co., has been transferred from the engineering department at Wilmington, Del., to the atomic energy division at the Savannah River Plant.

R. H. Christenson has been appointed sales and service representative of the chemical processing division in the east-central region for the Detrex Corp., Detroit. Mr. Christenson, a graduate of Purdue University with a degree in metallurgical engineering, has been in the chemical processing division of Detrex for almost three years.



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In a marching line, uniformity and precision are mandatory. Just as they are in alloys, selected for specific application in a wide range of manufacturing.

Riverside Alloys are uniform within the narrowest of limits. Get them in sheet, strip, rod, wire, blanks, circles . . . in phosphor bronze, nickel silver, cupro nickel, and beryllium copper.

Let our metallurgists huddle with yours. Write for the Riverside Handbook. Riverside *Alloys* are Industry's *Allies*. The Riverside Metal Company, Riverside, N. J. Branches in principal cities.

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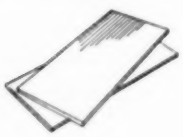


SHEET

STRIP

ROD

WIRE

Free pocket-size Alloy Handbook. Your reference and guide to Alloy specifications. Write today.

And real production economy sense, too!

The old axiom about "the chain and its weakest link" still holds true. It takes *top quality parts, all the way*, to economically produce dependable equipment. Today's market *demands* it . . . and your product rating *depends* on it! It makes sense!

Unitcast pours a *complete range* of *top quality* carbon and alloy steel castings up to 150,000 pound tensile strength. No matter what the end use . . . or whether your needs are twenty or twenty-thousand, Unitcast will deliver *top quality all the way*! Unitcastings, delivered in coordination with your production make sense! Call today!

Take advantage of Unitcast's foundry engineering services, too! Experienced technicians will help you originate . . . or convert present requirements to Unitcastings. No obligation, ask about this service!

UNITCAST CORPORATION • Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast QUALITY STEEL CASTINGS

Personals

E. F. Mactaggart, having sold his interest in Sondes Place Research Institute, Dorking, Surrey, England, of which he has been the director for the past seven years, has resigned from the board of Messrs. Mactaggart & Evans, Limited, the consulting firm of which he was co-founder in 1936.

Robert A. Stauffer was recently elected to the board of directors of National Research Corp., Cambridge, Mass., where he has been vice-president and director of research since 1949. He is also vice-president and a director of Vacuum Metals Corp., jointly owned by Crucible Steel Co. of America and National Research Corp. Mr. Stauffer was educated at Harvard University, receiving his B.A. degree in 1942, and has been associated with the corporation since graduation.

William J. Harris has joined the staff of Battelle Memorial Institute, Columbus, Ohio, as a consulting scientist and will serve in the office of the director in a liaison capacity between the Institute and its sponsors in government and industry. Dr. Harris comes to the research center from Washington, D. C., where he served for three years as executive secretary of the Minerals and Metals Advisory Board of the National Academy of Science and the National Research Council. Prior to his assignment with the M.M.A.B., Dr. Harris was head of the Ferrous Alloys Branch of the Metallurgy Div., Naval Research Laboratory, Washington, D. C. On active duty with the Navy during wartime, he was head of the Bureau of Aeronautics' Aircraft Armor Section. He has been associated with the studies for the Ship Steel Committee of the National Research Council, and is currently serving as chairman of the Advisory Committee for the National Bureau of Standards' project on examination of plates causing ship failure. A native of South Bend, Ind., Dr. Harris received his B. S. in chemical engineering and M. S. in metallurgy from Purdue University. He was awarded a Rockefeller Foundation pre-doctoral fellowship and in 1948 received the D. Sc. degree in metallurgy from Massachusetts Institute of Technology.

Announcing

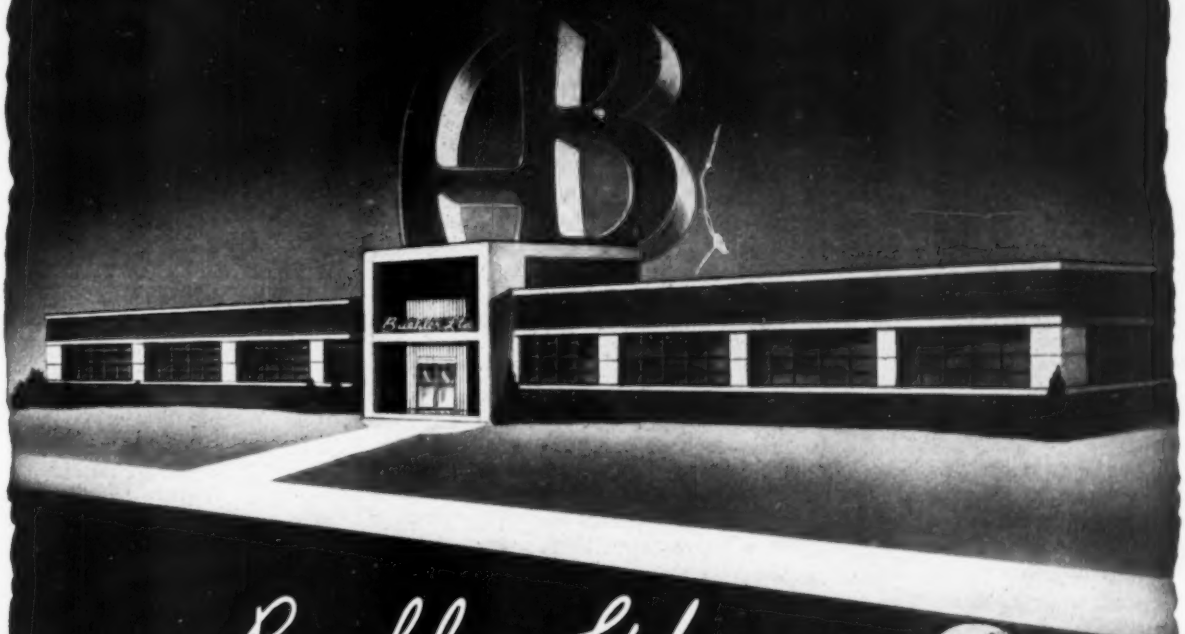
THE OPENING OF OUR NEW PLANT AT

2120 Greenwood at Hartrey Ave., Evanston, Ill.

JUST ONE BLOCK NORTH OF DEMPSTER STREET

These facilities have been arranged so that we can provide better equipment and better service for our customers. Changing your records now to show our new address may prevent annoying delays on future correspondence and orders.

We are delighted with the new building and location and will be pleased if you will take the next opportunity to visit us. A display will be available of our complete line of metallurgical sample preparation equipment, optical instruments for the laboratory, Amsler and Chevenard testing machines and other items.



Buehler Ltd.

METALLURGICAL APPARATUS

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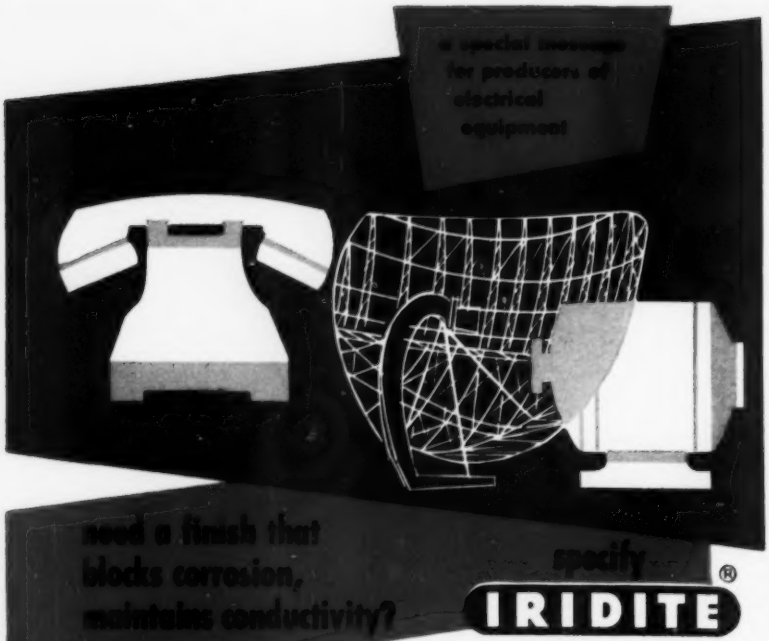
TELEPHONES: SHeldrake 3-1717 and DAvis 8-3032



need a finish that blocks corrosion, maintains conductivity?

specify ... IRIDITE®

Here's peak corrosion protection combined with conductivity, weldability and solderability. Here's a finish that holds paint firmly, prevents underfilm corrosion. Here's a line of attractive final finishes to add quality and sales-appeal. Here's Iridite . . . and here's how you can use it:

ON ZINC AND CADMIUM you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.

ON COPPER . . . Iridite brightens copper, keeps it tarnish-free; also lets you drastically cut the cost of copper-chrome plating by reducing the need for buffing.

ON ALUMINUM Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.

ON MAGNESIUM Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

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Manufacturers of Iridite Finishes for Corrosion Protection and Allied Systems on Non-Ferrous Metals, ABP Plating Chemicals, [illegible]

Blast Cleaning . . .

(Starts on p. 104)

throughout its life. Abrasion on wheel parts and wear plates by the rounded wire is much lower than that caused by cast iron shot, and approximately the same as with malleable and steel shot. The purchase price of clipped wire is high, but production economies are possible.

Metal Abrasive Sizes – Standard sizes of abrasives have been formulated by the Society of Automotive Engineers in cooperation with representatives of shot and grit suppliers, equipment manufacturers and automotive users. Shot (round balls) and grit (angular shapes) each have their respective ranges. This determination of sizes had to be established within the accuracy possible with commercial screening used by metal abrasive producers.

Shot and grit for cleaning cannot be screened accurately to one size only. Therefore, sizes are arranged in brackets, and each bracket bears a number corresponding to the aperture size of the nominal screen (in thousandths of an inch), this being next in sequence to the coarse screen for each bracket size. This screen is termed a body size, and consequently body size includes everything between coarse screen and second screen. The classification provides tolerances for the finer particles that pass through the second screen (body size). These finer sizes are not desirable, but must be accepted. In commercial screening

(Continued on p. 144)

Table I – Screen Aperture and Standard Screen Numbers

Screen Aperture, In.	Screen Number for Grit	Screen Number for Shot
0.132	—	1320
0.0787	G 10	780
0.0661	G 12	660
0.0555	G 14	550
0.0469	G 16	460
0.0394	G 18	390
0.0331	—	330
0.0280	G 25	—
0.0232	—	230
0.0165	G 40	170
0.0117	G 50	110
0.0070	G 80	70
0.0049	G 120	—
0.0017	G 325	—

Non-destructive inspection with a G-E x-ray unit insures a better product at lower cost

IF YOU'RE A USER OF CASTINGS, there's no need to buy blindly. With the all-seeing eye of x-ray, you can spot internal defects *before* costly machining. Even those deep-seated flaws that would not show up during machining can be eliminated as a source of potential failure of your product.

If you sell castings, on the other hand, x-ray inspection can protect your reputation — save your customers money and aggravation — give you a "plus" sales feature. In many foundries, x-ray is also used as a development tool — to disclose where savings can be made, designs improved, new techniques developed.

The possibilities for the profitable application of x-ray are as broad as industry itself. In addition to castings — weldments, intricate assemblies, the composition of the materials themselves can be checked.

Your G-E x-ray representative will be glad to analyze your requirements. With General Electric's line of 25 models, he can recommend the unit best suited to your needs. Call him today, or write X-Ray Department, General Electric Company, Milwaukee 1, Wis., Rm. A564.

General Electric x-ray apparatus can be yours . . . without initial capital investment . . . on the G-E Maxiservice® rental plan

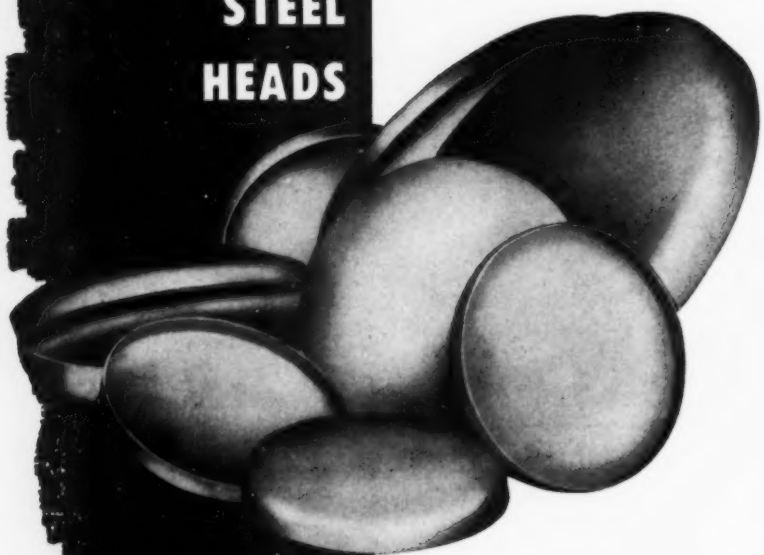
You can put your confidence in —

GENERAL ELECTRIC

"Heads-up" Service in STAINLESS STEEL HEADS

Fabricators rely on G. O. Carlson, Inc. for stainless steel heads produced to exact specifications and for other components of stainless steel tanks. Shells, flanges, rings, pads as well as spun or press-formed heads are readily available as a packaged service. This eliminates the need of multiple ordering from several suppliers and places responsibility in the skilled hands of Carlson specialists.

Carlson stainless steel heads are produced in a wide range



of sizes and gauges to ASME and standard specifications. Many styles of forming dies are available. There's an up-to-date folder describing these dies—write for your copy now!

Stainless Steels Exclusively

G. O. CARLSON, INC.

Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

THORNDALE, PENNSYLVANIA

District Sales Offices in Principal Cities

Blast Cleaning . . .

(Continued from p. 142)

the finer sizes increase in proportion with fineness of abrasive particles, for the reason that screening becomes more difficult. The relationships of grit and shot sizes with screen number and screen aperture, respectively, are shown in Table I on p. 142.

APPLICATIONS

More than half of the abrasives consumed each year is used to clean scale and foundry sand from ferrous castings. Different abrasives are chosen for different purposes, according to the shape of the part to be cleaned, surface finish desired, and type of blasting equipment used. Abrasives recommended for the removal of foundry sand and scale from ferrous castings are:

	Shot	Grit
Cast Iron	550 to 230	G 16 to G 40
Malleable	550 to 330	G 18 to G 40
Steel	660 to 390	G 14 to G 25

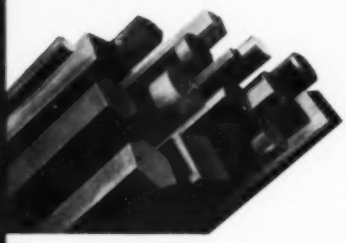
Another important use is for the cleaning of steel sheets and plates. For this purpose it is necessary to use decreasingly smaller abrasives for the thinner materials so as not to cause warping. Grit from G40 through the finer sizes to liquid media is used for the following thickness ranges:

Steel Thickness	Abrasive Size
0.25 to 0.1093	G 40 to G 50
0.1093 to 0.05	G 80 and finer
0.05 and less	Liquid Media

Armor plate, on the other hand, is usually covered with tough scale that requires G 14 to G 25 abrasive to break it loose and which can be used without harmful effects to the plate because of its greater hardness and thickness of section. Removal of tenacious weld spatter from castings requires a hard grit. In addition, a smooth finish and uniform coverage of the work are usually desired. For this work sizes between G 25 and G 40 are generally used.

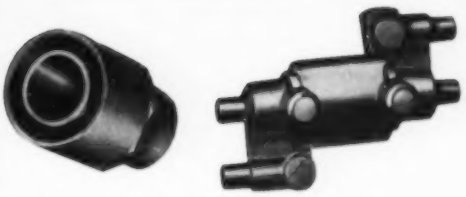
Rust and other corrosion products are generally removed by metal or sand abrasives. However, the less tenacious deposits can be cleaned with corn cobs, wood particles and other agricultural grits, particularly where metal surface is not to be disturbed. *(Continued on p. 146)*

Brass and Bronze Free-Cutting Rods



Furnished in all sizes from 1/16" for small-diameter rods up to 10" for cast and turned rounds. The most easily-machined of all metals and alloys.

Brass and Bronze Forgings



From 1/4 oz. to 100 lbs. in weight. Produced to meet requirements of uniform dimensions, finish and physical properties.

Extruded Brass Shapes

Squares, hexagons, half rounds, half ovals, and special shapes. Extruded-only rectangles furnished up to 5½" maximum diagonal. Extruded, drawn, machine-straightened hexagons up to 4", rectangles up to 3½" maximum diagonal.

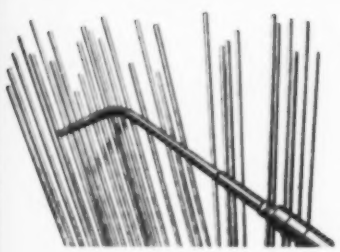
Brass Pressure Die Castings

Parts having thin sections and intricate cored parts readily produced. Titan die castings have better finish, stronger structure and greater accuracy than sand castings.

Titan Brass and Bronze Products

Titan brass and bronze products are supplied in analyses to meet every requirement. Write for descriptive catalogs.

Bronze Welding Rods



Eight different types meet all requirements. Titan's exclusive Double Deoxidation process assures ductile, high-strength, non-porous welds with the oxyacetylene torch.

Brass Cold Heading Wire

Brass wire for manufacture of rivets, bolts, screws, fasteners, etc.

Titan

METAL MANUFACTURING COMPANY

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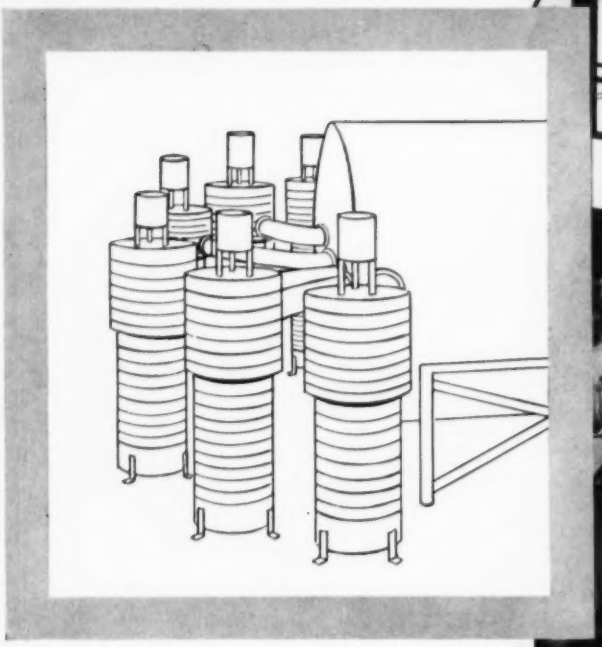
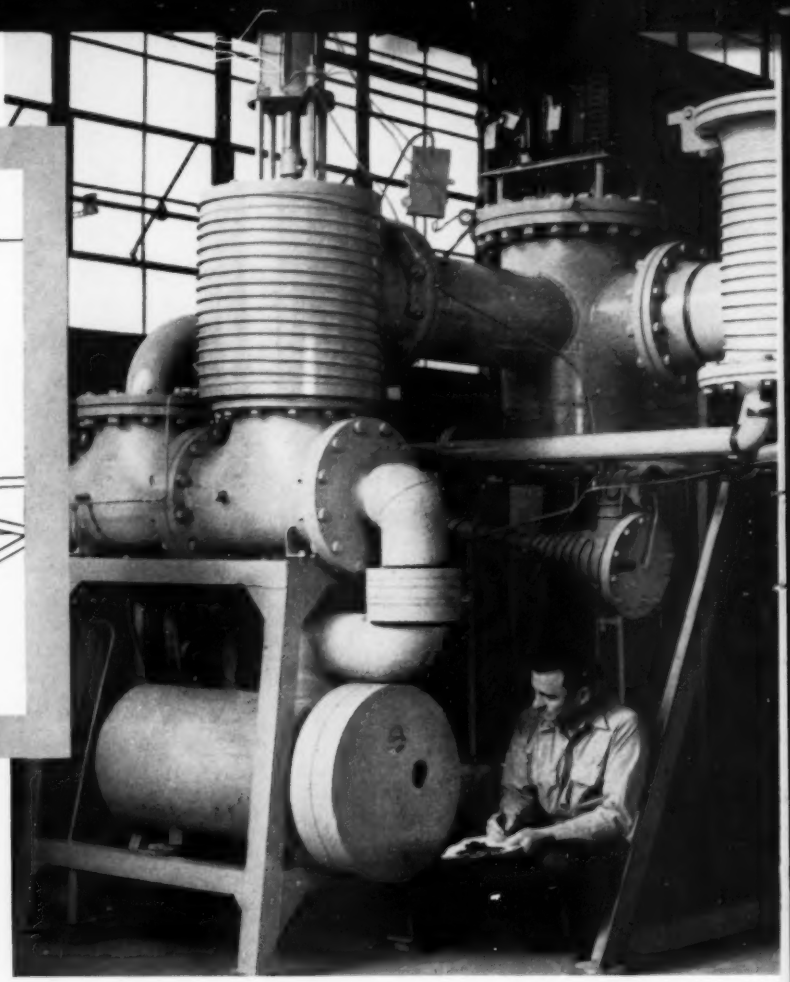
Quality Alloys by Brass Specialists





Which would you choose for *your* high vacuum furnace...

The wide jet clearances of this CVC type KB-1500 high vacuum pump suits it particularly to use on high vacuum furnaces. Its high-speed air removal rate is 2 lbs. per hour at 50 microns. It can produce an ultimate vacuum of 5 microns Hg. operating against a forepressure of .5mm Hg. A modified version, the type KS-1000, will produce an ultimate vacuum below .1 micron and has high pumping speed at 10 to 20 microns.

multiple small pumps or a *single* large pump combination?

The key to successful high vacuum melting and casting is LARGE CAPACITY *high vacuum pumping* in the *right* pressure range on a well designed flexible furnace.

The right range is anywhere from 300 microns (3×10^{-1}mm Hg) to 1 micron or lower absolute pressure—300 microns to take care of the inevitable burst of gas accompanying *any* melting operation—down to 1 micron or less to produce the final gas-free atmosphere so necessary to obtain high purity metals and permit adding the required alloying elements not possible at normal atmospheric pressure.

Only *CVC*'s Ejector or Diffusion-Ejector type high vacuum pumps will remove these large amounts of gas (from .5 to 13 lbs. of air per hour) over the entire pressure range, and generally do it with a single pump or at most two pumps in series.

Before you purchase a high vacuum melting and casting furnace in any size from 50 to 2000 lbs. of melt, contact *CVC*'s metallurgical and equipment design experts. ***Consolidated Vacuum Corporation, Rochester 3, N. Y.*** (a subsidiary of Consolidated Engineering Corporation, Pasadena, California).

CVC

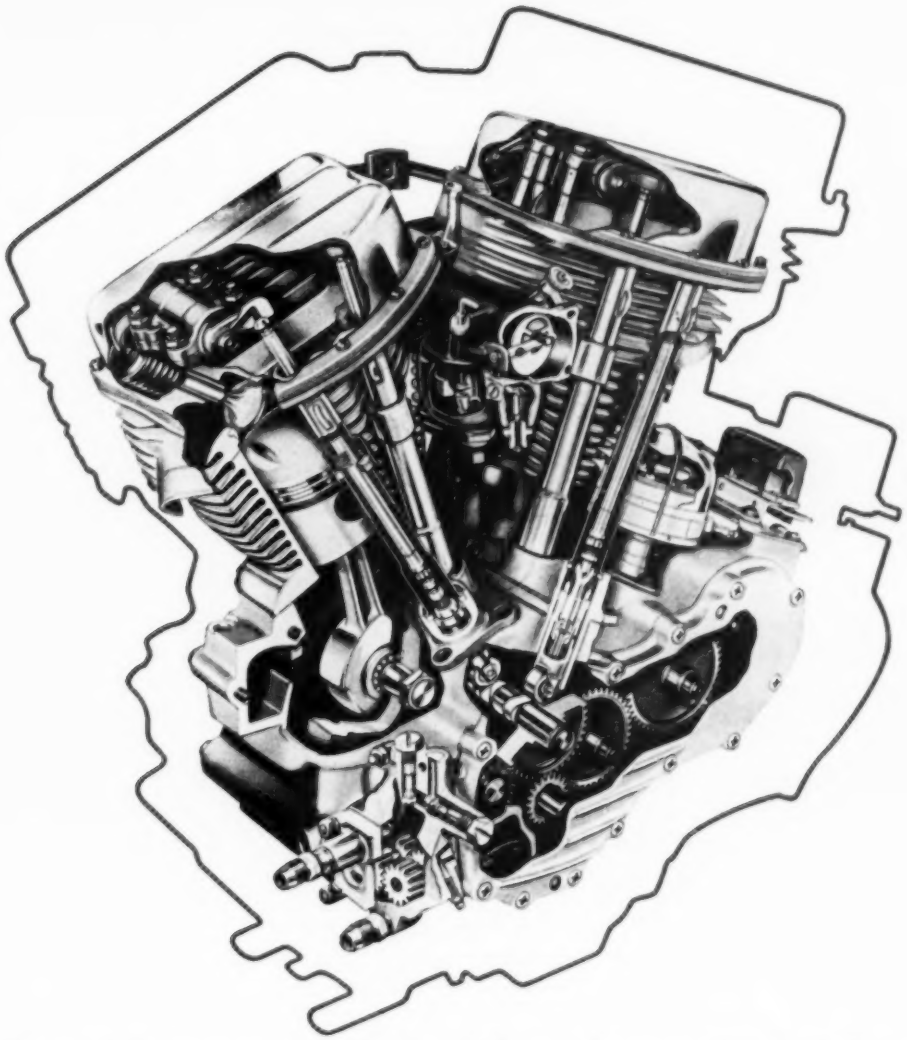
Consolidated Vacuum Corporation

Rochester 3, N. Y.

formerly DPi Vacuum Equipment Dept.

designers and manufacturers of high vacuum equipment

SALES OFFICES: NEW YORK, N. Y. • CHICAGO, ILL. • BOSTON, MASS. • CAMDEN, N. J. • PALO ALTO, CALIF.



What happens to the transmission when horsepower goes up?

Harley-Davidson faced the problem when it increased horsepower from 30 to 55. In a motorcycle, it usually means a bigger transmission. More steel. Maybe more parts. And more expense.

Company engineers, with the help of Republic metallurgists, took a good look at alloy steels. They chose Republic's 8617 for a lot of reasons. One of them was the reduction of section possible. Another was the good heat-treating and carburizing properties. Still another, it stood up well under the heavy strain of gear teeth.

And, most important, the transmission could stay the same size and still take tremendous impact and stress.

Get an idea from this? Lots of manufacturers have. Like Harley-Davidson, they looked into Republic Alloy Steels. Some of them cut costs. Others made better products. Others got a better competitive position. You can do the same. A call to your nearest Republic Sales Office is all it takes to get started.

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N.Y.

REPUBLIC ALLOY STEELS

J-M BLAZECRETE builds longer lasting refractory linings...

That's why it pays you to use this hydraulic setting refractory for temperatures to 3000F

Blazecrete* linings last longer because they resist spalling, withstand slagging action, and are not harmed by rapid temperature changes.

Thus you cut down on refractory maintenance costs—and you save on labor costs, too, because Blazecrete goes on fast. For troweling, just mix Blazecrete with water as you'd mix ordinary concrete . . . then slap-trowel it in place. When gunned, it adheres readily with a minimum of rebound loss. Either way, Blazecrete may be applied easily without laborious ramming or tamping.

Three types of hydraulic-setting Blazecrete are available. All harden on air curing, do not require prefiring. They are furnished as a dry mix—can be stored safely for use as needed.

3X BLAZECRETE—For temperatures through 3000F. Unusually effective for heavy patching, especially where brickwork is spalled or deeply eroded. Excellent for forge furnace linings, lime kilns, burner blocks, soaking pits, and industrial boilers.

STANDARD BLAZECRETE—For temperatures through 2400F. Makes repair work easier and less costly. Can be used by boiler manufacturers to replace fire clay tile in wall construction. Suitable for use in combination with 3X Blazecrete and L. W. Blazecrete.

L. W. BLAZECRETE—For temperatures through 2000F. An insulating refractory . . . light in weight, low in thermal conductivity. Adaptable and economical for many other applications.

Send for Brochure RC-28A on Blazecrete and its companion material, Firecrete*. . . the hydraulic-setting castable refractory for making special shapes and linings. Write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ontario.

*Reg. U.S. Pat. Off.

Whether you gun it... *or slap-trowel it...*

Johns-Manville **BLAZECRETE**

BUILDS BETTER REFRACTORY LININGS

Blast Cleaning . . .

(Continued from p. 144)

Paint removal is usually more satisfactory if the finish is smooth after cleaning, so that less paint will be required. For this application sizes G40 to G50 are used.

Surface cleaning for applied finishes is generally governed by the thickness of the finish to be applied. The thicker finishing coats require cleaning with a relatively coarse abrasive so as to provide a tooth for the coating. Most surface finish requirements are met with sizes from G18 to G40.

The cleaning of nonferrous castings requires care that the abrasive does not embed in the metal. For brass, bronze and magnesium castings, G50 malleable grit is recommended because of its softness and burnishing action. If shot is to be used, the size and kind recommended is S170 malleable.

Some blast-cleaning jobs may pose what seem to be special problems; when these arise, considerable help can be readily obtained from the equipment manufacturer.

Scale Additions Reduce Phosphorus and Nitrogen in Basic Bessemer Steel*

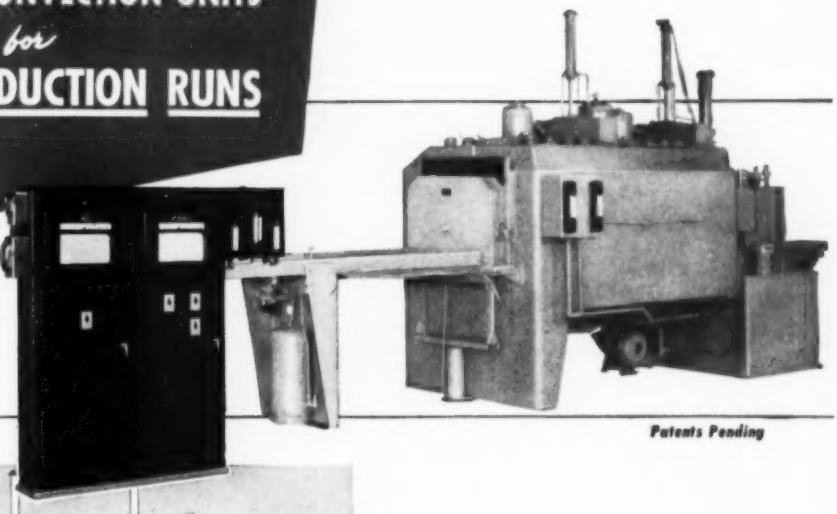
THE CORBY basic bessemer plant, built in 1934, has increased production from 224,000 tons in 1935 to 637,000 tons in 1952.

When it was decided to use the low-grade high-phosphorus Northamptonshire ores by building an integrated steel and tube works, two important decisions were made. The first was to adopt acid burdening practice in the blast furnace; the second, to choose the basic bessemer process of steel production which had been virtually abandoned a good many years earlier. When seamless tube came off the mill with all the characteristics of brittleness due to work hardening, first-aid remedies

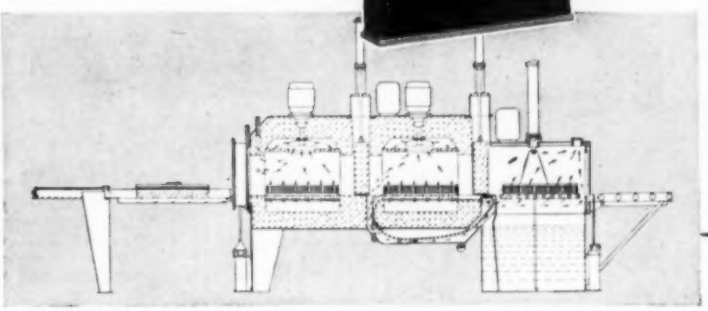
(Continued on p. 148)

*Digest of "Development at Corby of Basic Bessemer Steel Low in Nitrogen and Phosphorus by Scale Additions During the Blow", by W. A. Smith, *Journées Internationales de Sidérurgie*, April 1953, p. 547 to 562.

100% FORCED CONVECTION UNITS for Heavy PRODUCTION RUNS



Patents Pending



◀ The Ipsen 800 Lb./Hr. Automatic Heat Treating Unit. Features two heating chambers. Hearth dimensions are 24" wide x 36" long x 18" deep. Maximum operating temperature is 1850° F.

Ipsen STANDARD UNITS NOW AVAILABLE UP TO 2000 LB./HR. CAPACITY

Shown above is the Ipsen 800 Lb./Hr. Automatic Heat Treating Unit, typical of a proven line of furnaces designed for heavy production requirements. The Ipsen T-800 economically provides quality heat treatment of a larger volume of workpieces . . . from smallest screws to the largest gears. Among advanced engineering features of the T-800 are:

1 **Automatic Loader**—which also acts as transfer mechanism to move work load from first to second heat zone without loading delays. Movement of load from second zone to cooling-quench chamber is done automatically by Ipsen cold chain drive.

2 **Totally Enclosed Cooling-Quench Chamber**—Controlled atmosphere in both heat and quench zones gives you bright, scale-free results.

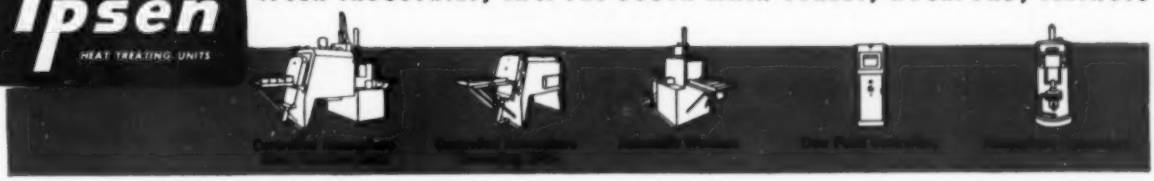
3 **Two Independent Heating Chambers**—with separate controls. Heating by radiant tubes, located in back of baffles, eliminates radiation from tubes to workpieces. 100% forced convection heating!

4 **Engineered for Versatility**—Each self-contained Ipsen Metal Treating Unit can harden, carburize, carbon restore and carbonitride.

For More Data—Write today for specifications and descriptive literature. If you desire, send samples of your work for processing and for an estimate of cost.

AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. 723 SOUTH MAIN STREET, ROCKFORD, ILLINOIS



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LABORATORY FURNACES

BURRELL *DUAL-RANGE*

Box and Muffle Type

FOR HIGH TEMPERATURES UP TO 2650° F.

Model 30 (pictured) Automatic temperature control. From 600° F. to 2000° F., use for ashing, drawing, igniting, tempering, etc. Above 2000° F., for sintering, melting, clinkering, fusing and high speed hardening. For use with 230 volt, 50-60 cycle, single phase power supply; automatic controller for 115 volt, 50-60 cycle, single phase.

CAT. NO.	ITEM	PRICE
37-442	Box Muffle Furnace, Model 30— (Heating chamber 7" wide x 8¼" deep x 4" high)	1300.00

For other models—ask for Bulletin No. 315

BURRELL *UNIT-PACKAGE*

Tube Furnaces

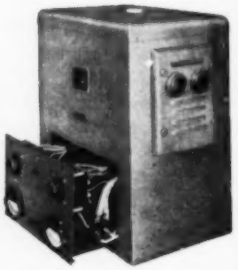
MODEL H-1-9 (pictured) For high temperature testing to 2650°F. For the determination of carbon and sulfur by combustion in ferrous metals. Available for one, two and four tubes. For use with 115 or 230 volt, 60 cycle, as specified.

CAT. NO.	ITEM	PRICE
24-934	One Tube Furnace, Model H-1-9	585.00
24-944	Two Tube Furnace, Model H-2-9	600.00
24-954	Four Tube Furnace, Model H-4-9	850.00

For other models—ask for Bulletin No. 310

EASY ACCESS PANELS FOR EASE OF SERVICING

All current models of Burrell furnaces open from the front, for ease of inspection, parts replacement and servicing when necessary.



Prices listed are F.O.B. Pittsburgh, Pa.

BURRELL CORPORATION

Manufacturers and Distributors of
SCIENTIFIC APPARATUS and LABORATORY CHEMICALS
2223 Fifth Avenue, Pittsburgh 19, Pennsylvania

Basic Bessemer . . .

(Continued from p. 146)

were quickly found empirically. Serious brittleness was confined to tubes which were reeled off the mandrel at a black heat. However, avoidance of delays and immediate reheating to at least 1200° F. of all tubes after reeling solved the pressing difficulties.

A preliminary study revealed that phosphorus and nitrogen were probably responsible. Four main lines of investigation followed: removal of nitrogen from the liquid steel for which a precedent already existed in duplexing; fixation of nitrogen in an innocuous form, as by aluminum or titanium; removal by diffusion from solid steel; fourth, and most important, prevention of absorption during the steelmaking process.

As a result of the laboratory investigations it became clear that low-nitrogen steel depends chiefly on:

1. Low partial pressure of nitrogen in the blast.
2. Low blast pressure, but with the same or increased rate of supply.
3. Short time of contact between blast and metal.
4. As low a finishing temperature of the metal as possible, consistent with good teeming.

Restricted capital available for investment ruled out the possibility of a tonnage oxygen plant of the type then proving so successful for cheap oxygen production in the United States. The objective was not necessarily to achieve parity with open-hearth steel, but to reach a stage where satisfactory performance in the use of tubes and cold rolled strip could be assured. A nitrogen content of 0.010% appeared adequate. It was decided to control all factors mentioned above within the limits of the existing plant.

Trials with mill scale indicated that this material could be used to enrich the bath with oxygen. The nitrogen was as low as with additions of iron ore and more consistent. Some improvement in sulphur was obtained. In view of the high thermal characteristics of the pig iron, most normal blows at Corby have scrap additions for temperature control and increased production. Weight-for-weight, scale has a greater cooling effect than scrap, and with high-

(Continued on p. 150)

formula for lowest heat-hour costs:

SPECIFY DRIVER-HARRIS ALLOYS

. . . follow the maker's operating instructions

Regardless of what alloy your heat-treating equipment is made of, it will pay you well to heed closely the manufacturer's operating instructions.

Many users of D-H alloy retorts, muffles, and liquid pots have heeded this advice—and the figures show the benefits they received.

1. They avoided thermal shock by heating the containers *slowly* to the recommended temperatures before starting work.

2. They did not let them go completely cold over week-ends or between work periods.

They realized that fine equipment is cheaper than fuel . . . that the added life of the containers is well worth the moderate expense of keeping them at correct idling temperatures when not in use.

This advice will serve you well—to repeat—no matter what alloy you are using. Of course, for the absolute maximum in long life . . . the lowest heat-hour costs . . . it would be well at the outset to specify Nichrome, Chromax, or Cimet, alloys with a consistent history of outstanding performance.

Nichrome, Chromax*, Cimet* are manufactured only by*

Driver-Harris Company

HARRISON, NEW JERSEY

*T. M. Reg. U. S. Pat. Off.

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Louisville

MAKERS OF WORLD-FAMOUS NICHROME AND OVER 80 ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING FIELDS

automatic protection
or control
for your
heating process
...with
ALNOR PYROTAC

Here's a simple, low-cost way to obtain *AUTOMATIC PROTECTION* against damage due to excessive temperatures... safeguard your investment in heating equipment and materials in process. This precision-built instrument constantly indicates temperature of the heated equipment and sounds an alarm and/or shuts down the heated circuit at a safe, pre-set temperature. It may also be used as a *CONTROLLER* on a process requiring shutdown upon reaching a final process temperature—such as ceramic kilns, molds, etc. Automatic thermocouple break protection assures safety if couple or extension wires should break.

Ask your Alnor representative for details on this sturdy, precise instrument. You'll find the price of less than a hundred dollars unusual for an instrument of this type. Write for bulletin that contains complete description and wiring diagrams of actual applications. Illinois Testing Laboratories, Inc., Room 523, 420 N. LaSalle Street, Chicago 10, Ill.

Alnor

ILLINOIS TESTING LABORATORIES
PRECISION INSTRUMENTS FOR EVERY INDUSTRY

Basic Bessemer . . .

(Continued from p. 148)

silicon irons, scale additions are more reliable for temperature control.

The quantity of scale to be added for any blow cannot be predicted exactly. Correct final temperature, and the required low nitrogen and low phosphorus contents, depend on the correct relation with many factors in the blowing process. The blower controls the charges and additions according to iron composition, temperature, and the condition of the lining and bottom. In normal blows, the scrap is added before blowing or after the silicon removal – according to the silicon content of the iron and crane availability. With scale additions, slightly lower nitrogen results if the addition is made nearer to the flame drop. The effect of scale added to the start of blowing persists throughout the later stages of the blow. Where the scale weight exceeds 3000 lb., two additions are made, one at the start and one during the foreblow.

The lime charge to the converter varies between 7000 and 7800 lb. according to the weight of iron charged. The proportion of lime is the same for both normal and scale blows. The weight of scale can be the same, or slightly less, than the weight of scrap that could normally be used. The extra cooling effect of the scale gives a slightly lower finishing temperature which is an advantage for low nitrogen. Scrap and scale additions are generally between 3 and 8% by weight of the iron charge, depending on the blowing conditions.

Blowing times for normal blows vary from a 10 to 14-min. foreblow, and an afterblow of 3 to 4½ min. For the scale blows total blowing time is shorter by 1 to 2 min. despite lower phosphorus specification.

Normal blown metal temperatures are within 2910 to 2950° F. and scale blows are 50 to 60° lower. For normal 5-ton top-poured ingots these temperatures leave only a slight trace of skull. Up to 560 lb. of ladle skull is considered ideal.

No changes in practice are required in hot rolling. In 1952 the average good ingot yield was 86.8% for both normal and scale blows. Dressing of the rolled bar is generally

(Continued on p. 152)

The Park Neutra-gas Story:

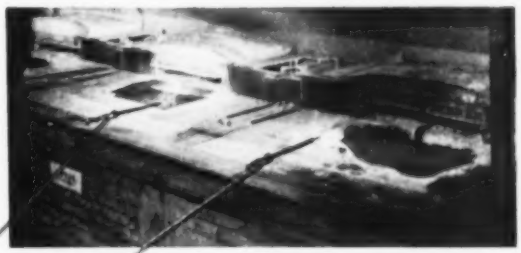
No sludge, no de-carb in neutral salt baths rectified by Park's patented process!*

A patented development of Park's research laboratory, the Neutra-gas process efficiently and economically neutralizes chloride base salt baths . . . maintaining them free of de-carb in temperatures ranging from 1350°F. to 2300°F. The decarburizing oxides present are chemically converted back to chlorides by passing methyl chloride through the molten baths.

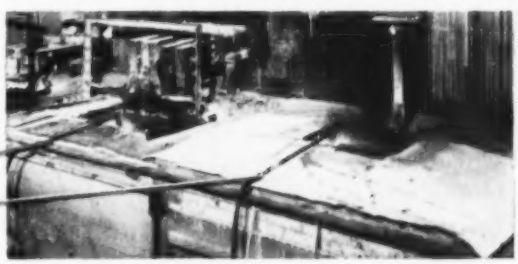
No solid rectifiers and their subsequent sludging are needed. No fresh salt additions are required except to replace drag-out. Fluidity of salt is maintained like new and sluggishness caused by solid rectifiers is eliminated.

Complete details of the Neutra-gas process plus valuable information on neutral salt baths, their operations and uses, are described in a technical bulletin available to you by mailing the attached coupon.

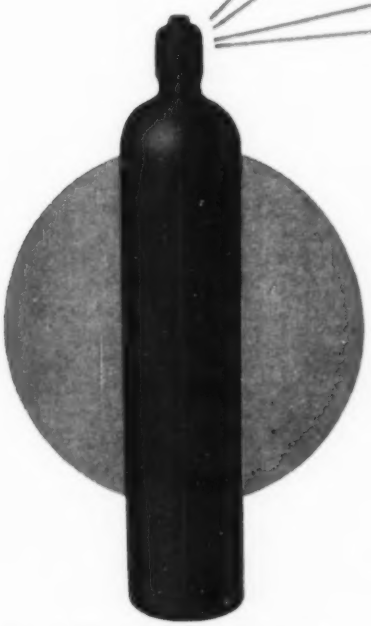
* Truly neutral chemically. Alkalinity can be maintained at zero.



At Commercial Steel Treating Corp., in Detroit, salt bath furnaces are daily cleansed of all impurities. Rectifying gas is bubbled into Park Nu-Sal Neutral Salt molten at its operating temperature of 1500°F.



Even high-speed hardening baths up to 2300°F. are easily maintained neutral. At Commercial, both pre-heat and high heat are rectified daily to zero alkalinity. Rectification is at 1850°F. in the high heat, done either on idling time or when furnaces are being used for hardening high carbon, high chrome die steels. Salt is Park Pre-heat 117, and Park High Heat 175-S.



Methyl Chloride (CH_3Cl) is a liquefied gas, 99.98% pure (by weight).

Patent number—2474680—Neutra-gas Process license fee, $25.00 per year.

Third in a series of advertisements describing Park processes on the job.

• Liquid and Solid Carburizers • Cyanide, Neutral, and High Speed Steel Salts • Coke • Lead Pot Carbon • Charcoal • No Carb • Carbon Preventer • Quenching and Tempering Oils • Drawing Salts • Metal Cleaners • Kold-Grip Polishing Wheel Cement

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Circo again leads the way with the most modern and talked about metal cleaning development of the century. The new Circosonic Degreaser, equipped with General Electric ultrasonic generator, cleans metal parts by the power of sound—faster than ever thought possible and to a degree of cleanliness that passes the most stringent industrial standards. The Circosonic degreaser may fit your operating needs.

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PER-SOLV (Perchlorethylene) CIRCO-SOLV (Trichlorethylene)

Vapor Degreasers • Metal Parts Washers • Dryers • Solvent Recovery Stills

Basic Bessemer . . .

(Continued from p. 150)

heavier for scale blows because of the lower casting temperature.

For day-to-day works use, the Stromeyer formula of $(P + 5N) \times 1000$ gives a simple and effective index that can be used to grade the steels for our applications. During 1952 the median value of this index was 75 with a spread from 50 to 110; 90% of the scale blows had an index below 90.

An experimental series of 400 blows was made during 1949 using air enriched with oxygen, 300 of these being scale blows. To eliminate the effect of variations in oxygen, the nitrogen contents of all blows were changed to an oxygen value of 0.06% using a linear relation between oxygen and nitrogen content. The effect of temperature on nitrogen content is given by the relation $\log N = -9000/T +$ a constant. For normal blows the constant is 2.85 and for scale blows it is 2.65. The relation between blowing rate and rate of oxygen supply was not with the volume of oxygen blown per minute but with the somewhat curious value

$$\sqrt{\frac{\text{oxygen in blast}}{\text{blowing time in minutes.}}}$$

It is not always possible with low-silicon irons to charge the full desired weight of 160 lb. of scale per ton of iron (for example, 2 tons of scale to a 25-ton charge) because the bath would be chilled. Scale practice can be combined with enriched air, however, to permit a greater scale addition for a given silicon content of the iron. When the bath has been blown to a normal phosphorus content of 0.05%, the slag in scale blows contains only about 8% iron and is not fully fluid. The steel is in a semi-oxidized condition and is semikilled in the molds. The blow is therefore continued until the iron content of the slag is 12 to 14%. The phosphorus is then generally under 0.03%.

There is a wide range of processes from which to choose in considering future developments at Corby. Installation of a tonnage oxygen plant is attractive technologically and would enable the production of a product with complete similarity to openhearth steel. The scale process, however, at a cost of under 33c per

(Continued on p. 154)

ACCUMET PRECISION INVESTMENT CASTINGS

are available in all steel and high-alloy grades...

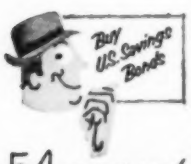
Whatever the grade of steel or high-alloys your specifications call for, you can get it in Crucible ACCUMET® precision castings.

And you can depend on the quality of ACCUMET castings, for they are made by the Country's leading specialty steel producer . . . to long established steelmaker's melting standards, in modern electric furnaces. The composition of ACCUMET is carefully controlled by chemical analysis of the *casting* — not merely of the remelt stock charged into the furnace. This extra control of analysis means better uniformity in response to heat treatment, hardenability and performance.

Put an end to costly machining of parts. Let your Crucible representative show you how ACCUMET precision investment castings can save you time and money.

Here are some of the more popular grades used for Crucible ACCUMET precision castings

AISI 1010 — Magnetic Iron
AISI 1020 — Low Tensile
AISI 4620 — Carburizing
Mod. 4140 — Medium to High Tensile
Ketos Oil-Hardening Tool Steel
HYCC Air-Hardening Tool Steel
Rezistal 410 — Hardenable Stainless
Rezistal 303 — Free Machining Stainless
Rezistal VT — AMS 5385B High Temperature
Rexalloy — Cr-W-Co Alloy
Alnico Magnets



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CRUCIBLE first name in special purpose steels

ACCUMET PRECISION CASTINGS

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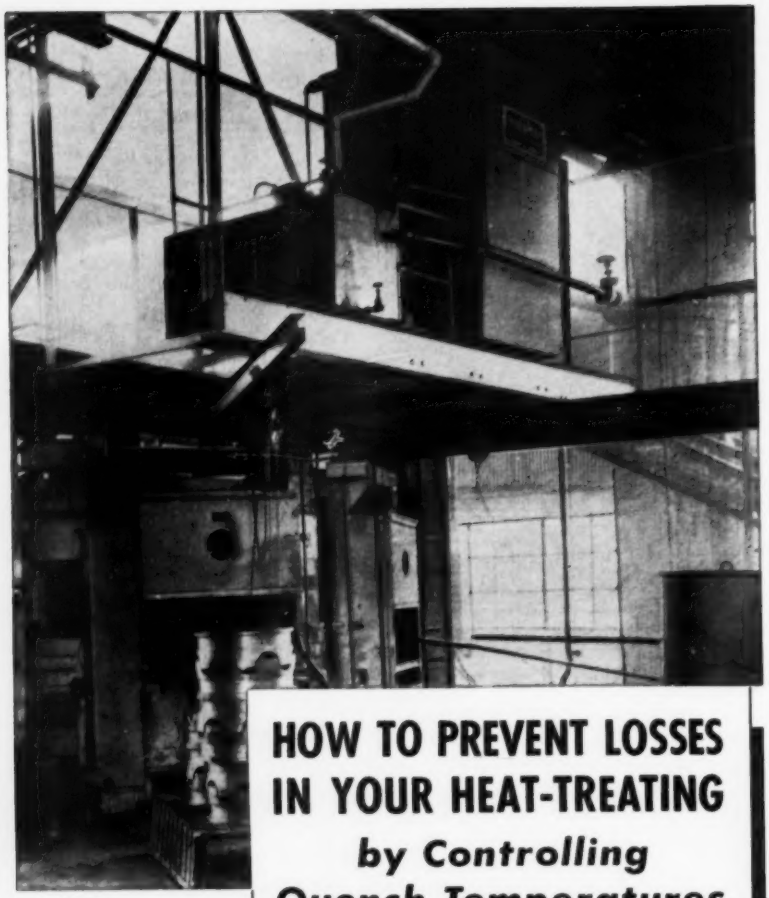
REX HIGH SPEED • TOOL • REZISTAL STAINLESS • ALLOY • MAX-EL • SPECIAL PURPOSE STEELS



HOW TO PREVENT LOSSES IN YOUR HEAT-TREATING

by Controlling Quench Temperatures

● Using Niagara's AERO HEAT EXCHANGER to cool your quench bath never fails to give you real control of the temperatures at which you wish to quench.

Your experience will be the same as others who have installed this method. You'll get better physicals; save losses and rejections; increase heat-treating capacity and production with lower costs. You can put back heat into the quench bath to prevent the losses of a "warm-up" period. You remove heat at the rate of input and prevent flash fires in oil quench baths.

You'll save space in your heat treating department and get a more productive arrangement because less room is needed for coolers and tanks. You'll find savings in piping, pumping and in the amounts of oil you will have to buy. And the saving in the cost of cooling water alone is enough to repay the cost of the Niagara Aero Heat Exchanger, usually in less than two years.

Write for Bulletin 120 and further information

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Niagara District Engineers in Principal Cities of U. S. and Canada

INDUSTRIAL COOLING HEATING • DRYING

NIAGARA

HUMIDIFYING • AIR ENGINEERING EQUIPMENT

Basic Bessemer . . .

(Continued from p. 152)

ingot ton over blowing, has almost eliminated embrittlement troubles. The need for oxygen enriched blowing in its various forms must be based on other considerations.

The growing dependence of the British steel industry on pig iron instead of scrap, and the resulting increase in use of home ore high in phosphorus, make the basic bessemer process at least technically more attractive. If the trend continues, there may well be an increasing urge to produce bessemer steel fully equivalent to openhearth. The pace, however, may be set by the engineer, whose thought – as reflected in British and American standard specifications – has thus far favored openhearth steel. Breakdown of these prejudices will open a much wider field to the basic bessemer process.

FRANK G. NORRIS

Steels for High Temperatures*

CREEP TESTS at 1200 and 1470° F. were made on a steel containing 0.25 C, 1.63 Mn, 1.03 Si, 46.52 Ni, 20.5 Cr, 2.73 Mo, 3.33 Co, 2.92 Cb, 3.52 W and 1.20% Ti, and on steels having a similar basic composition (carbon, manganese, silicon, nickel and chromium) but without one or more of the other elements, or to which 0.73% V was added. Tests at 1200° F. and 44,800 psi. showed that the absence of titanium or tungsten seriously lowered the resistance of the steel to creep, and that the omission of columbium was only less serious. The omission of cobalt or molybdenum, however, was very slightly beneficial, but no difference was observed for vanadium additions. For tests at 1470° F. and 5600 psi. it was found that creep resistance of steels without columbium or titanium was greatly impaired, and was almost as badly affected by the absence of cobalt. Tungsten and molyb-

(Continued on p. 156)

*Digest of "Special Steels for Gas Turbines", by W. E. Bardgett and G. R. Bolsover, Symposium on High-Temperature Steels and Alloys for Gas Turbines, Iron and Steel Institute, Special Report No. 43, 1952, p. 135-148.

Only Yoder-TOCCO Makes *Welded Tubing* at 250' per minute in Regular Production

Yoder—TOCCO mills, using the patented TOCCO Process for welding ferrous pipe and tubing are actually producing pipe at speeds of 150 to 250 feet per minute. This rate is almost twice as fast as any other cold forming pipe mill in production anywhere in the world. *Check these advantages:*

- ✓ **A production speed of 250' per min.**
- ✓ **lower cost because of increased production and lower maintenance.**
- ✓ **a smooth, continuous weld—no stitching.**
- ✓ **an extra strong weld—because it's 100% uniform and continuous.**
- ✓ **no scaling of ferrous tubing.**
- ✓ **controlled weld flash—either I. D. or O. D.—or in some cases none.**

Whether it's welding, heat-treating, brazing, melting or heating for forging operations, it pays you to investigate TOCCO Induction Heating as a means to better products, faster and at lower cost.

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Please send copy of "TOCCO Induction Heating"

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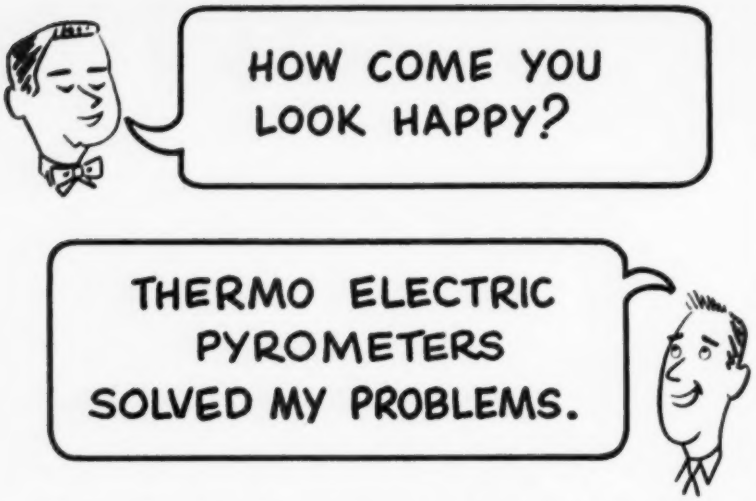

Thermo Electric makes many products that help solve problems in the field of temperature measurement and control. T-E controllers and indicating-recorders are good examples. They are both made in two types: potentiometer pyrometer and resistance thermometer. They are accurate (±¼ of 1% of the range), rugged, simple in design, easy to maintain. Ranges from −100° — +600°F up to 0 — 3000°F.

THERMO ELECTRONIC INDICATING-RECORDER

Only three moving parts in the recording system—pen arm is driven from a cam, which permits linear charts to be used for all temperature measurements —full scale pen travel only 4 seconds. Easily adapted to measure humidity, solution conductivity, speed, pH, direct current, DC voltage, or other variables.

THERMO ELECTRONIC CONTROLLER

Two-position control action is continuous and instantaneous — potentiometer pyrometer type is sensitive to changes of as little as ±1.5°F, or less; resistance thermometer type is sensitive to changes of as little as ±0.1°F.

Write for details:

controller, potentiometer pyrometer type, bulletin 50-H
controller, resistance thermometer type, bulletin 55-H
indicating-recorder, both types, bulletin 60-H

Pyrometers • Thermocouples • Protection Tubes • Quick-Coupling Connectors
Thermocouple and Extension Wires • Resistance Bulbs • Connector Panels

Thermo Electric Co., Inc.

SADDLE RIVER TOWNSHIP, ROCHELLE PARK POST OFFICE, NEW JERSEY
IN CANADA—THERMO ELECTRIC (Canada) Ltd., BRAMPTON, ONTARIO

High Temperatures . . .

(Continued from p. 154)

denum had little effect and vanadium was detrimental. It was concluded that for a range of temperatures, all the alloys except vanadium should be used. Also, the effects of different amounts of working and heat treatment on the properties of the steel were determined, and it was learned that a higher heat treating temperature (2280° F. as against 1920° F.) imparted better creep resistance.

A steel containing 0.08 C, 19 Cr, 30 Ni, and 1.6% Ti had excellent strength when air cooled from 1920° F.; however, with 1.1% Ti the creep resistance was much better after air cooling from 2280° F., but showed no further improvement with the use of a temperature of 2370° F. In rupture tests at 1290° F. and 34,720 psi., failures occurred as follows:

	Air Cooled From	
Ti, %	1920° F.	2280° F.
0.90	3.3 hr.	4.9 hr.
1.17	15.6	167
1.60	48.8	348

In creep tests at 1120° F. and 26,880 psi., negative creep was observed; this condition persisted for 1000 hr. Dimensional instability, evidenced by contraction, was characteristic of the solution treated condition, and was less after precipitation hardening. G. F. Comstock

Ventilators Flame Brazed to Aluminum Roofs*

Effecting water-tight joints beteen light-gage aluminum alloy ventilator sleeves and corrugated roof sheets for Nissen-hut units (similar to the U.S. Quonset huts) by means of low-temperature flame brazing is an unusual accomplishment in that the method hitherto has been confined to much smaller assemblies, such as those encountered in the radio, electrical appliance and utensil fields.

In this contract for the British Ministry of Supply, roof sheets originally were of 24-gage corrugated sheet steel, hot dip galvanized, 6 ft. in length and 26 in. wide, curved to

(Continued on p. 158)

*Digest of "An Unusual Application of Aluminum Flame Brazing," by F. J. M. Smith, *Sheet Metal Industries*, Nov. 1953, p. 935 to 942.

CONTINUOUS STRIP ANNEALING in DREVER VERTICAL FURNACES

Saves Time • Reduces Cost

Outstanding PRODUCT

A Uniformly annealed strip from edge to edge and end to end of coil

B Uniform Physicals throughout the coil

C Clean, Lustrous Surface that electro-tins uniformly

D Stickers and "Dog Ears" eliminated

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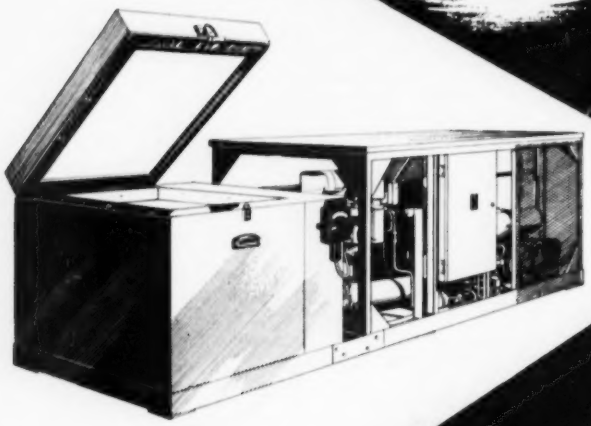

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DIVISION BOWSER, INC. TERRYVILLE CONNECTICUT

Brazing Aluminum . . .

(Continued from p. 156)

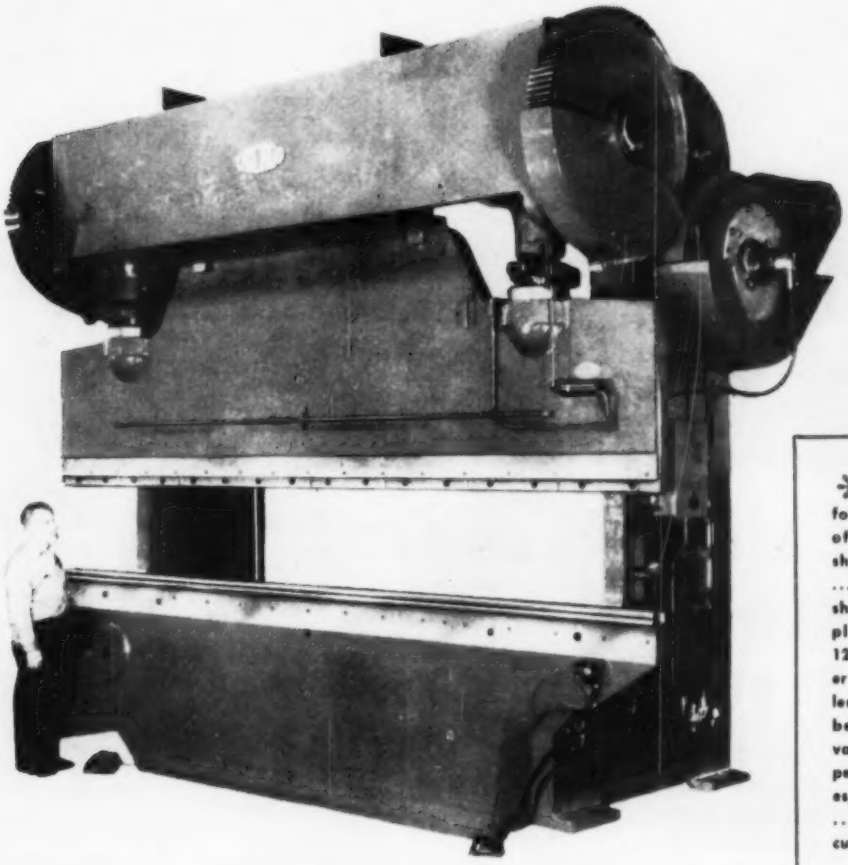
the arc of the roof. A tapered sleeve, 7½ in. diameter at the top, 8⅝ in. at the base and 9 in. high, and of 22-gage flat steel, was formed and inserted in a hole cut into the roof sheet 11 in. back of the roof centerline, then welded to the sheet on both sides. Material shortages forced a change in specifications to 99.4% pure commercial 22-gage aluminum, for both roof sheets and "chimneys".

Welding the aluminum was impractical because of the danger of trapping corrosive flux in the joint and of burning through the thin-gage metal while attempting to guide a welding torch around the corrugated contour of the joint. An alternative considered was to form a narrow upward flange in the roof sheet while it was locked in suitable dies, and then to fit the sleeve over the flange and rivet. The lower edge of the sleeve would have been developed accurately to match the corrugations and downward slope of the hole. However, fracturing of the sheet metal while the flange was being worked up, along with the difficulties of annealing so large a piece to relieve the strain hardening, forced the discard of this idea.

The fabricator ultimately turned to flame brazing. The lower edge of the sleeve was developed in the flat as before, treating the job as a "right-cone frustrum" penetrating a cylinder, with the center line of the frustrum not passing through the center of the cylinder, as viewed along the central axis of the cylinder. The tapered sleeve was the frustrum and the corrugated sheet an arc of the cylinder, the sleeve penetrating only to the depth of the corrugations. After being cut from a pattern, the sleeve was rolled to shape and the edges interlocked. An internal grooved seam was rolled circumferentially about 1⅛ in. below the top edge for strengthening.

A 4-in. pilot hole first was cut into the roof sheet at the proper point, using an oxy-acetylene torch. The hole was enlarged to correct shape and size by using a tension file fitted into a hacksaw frame. The sheet was held by the cast iron dies previously used in attempting to form a flange on the hole. Joint sur-

(Continued on p. 160)



* Operations include forming, gang-punching of irregular and special shapes, channels, angles ...bending of bar, pipe, sheet ...from mild steel plate up to 1/2" thick, 12', 6" long, and greater thicknesses in shorter lengths. Fabrications may be material handling, vats, alloy, bins and hoppers, tanks, vessels, boxes, frames, retorts, muffles ...and a hundred other custom-built products.

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Brazing Aluminum . . .

(Continued from p. 158)

faces were cleaned thoroughly with steel wool before the assembly was fitted together and tack welded on the underside at four points, using pure aluminum welding rod of 3/32-in. diameter and aluminum flux.

Preheating is necessary for good flame brazing, so a gas burner ring was devised, to be set up directly beneath the assembly, 12 in. from the joint, with the flame adjusted to burn blue. By this method of soaking heat into the joint and surrounding metal, it was feasible to carry out the brazing on the top side with little delay.

A 10% silicon-copper-aluminum brazing rod ¼ in. in diameter having a melting point of 1025° F. as contrasted with 1215° F. for pure aluminum, was found to give sufficient temperature differential to avoid melting and possible collapse of the parent metal. The joint was heated with the inner flame of the torch held about 2 in. away, until the powdered flux began to flow freely along it, flux being supplied by first "tufting" the end of the filler rod. As soon as the filler metal began to flow, the blowpipe was brought toward the joint until almost in normal welding position, and at the same time it was moved forward and away in a sweeping or punching action. During the operation the filler rod ran up the grooved seam to a height of ¾ in. by virtue of the capillary action.

The complete 30-in. joint was brazed in one continuous travel, with only 5 in. of rod being consumed. Time required, not including set-up, was only 3 min. No perceptible distortion of the assembly was observed. A single fluxing of the rod was sufficient for depositing 6 in. of metal from it. Flux was removed from the aluminum by scrubbing with hot, soapy water.

Each assembly of roof sheet and sleeve weighed about 6 lb. as against 16 lb. for steel. In all, some 610 units were brazed, each successfully meeting a prescribed test of pouring molten paraffin around the joint and examining for possible seepage. Later, attempts were made to braze the vertical seams in the sleeves, using both butt joints and lap joints. However, they were unsatisfactory because of buckling during brazing.

A. H. Allen

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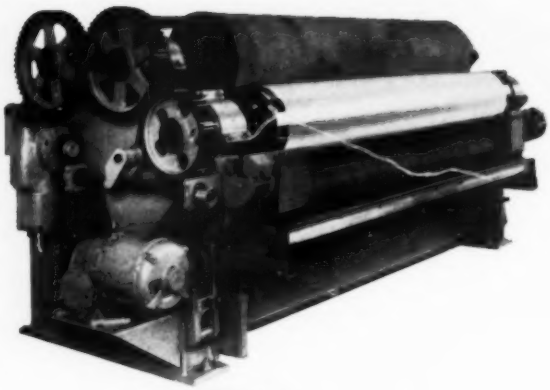

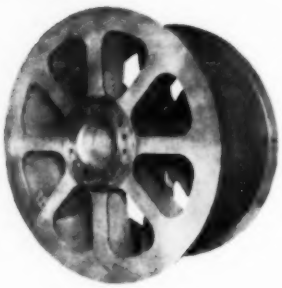

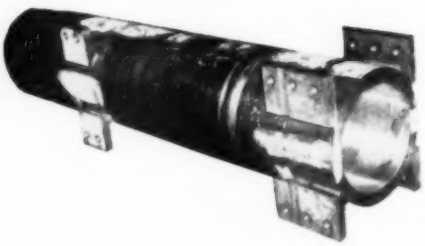

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Report of Symposium on Wear and Abrasion*

THE PROCEEDINGS of the International Symposium on Abrasion and Wear, held in 1951 to inaugurate the new premises of the Rubber-Stichting (Rubber Research Station) at Delft, Holland, have been published in *Engineering* (London). A total of ten papers, complete with discussion, appear in these proceedings, but only a few are likely to interest the metallurgist.

F. P. Bowden ("Friction and Surface Damage of Nonmetallic Solids") emphasized the simple but very important point that the frictional behavior of so-called "clean" nonmetallic solids, as normally studied, is determined more by the presence of surface films than by the nature of the solid itself. In discussion of this paper, W. Späth noted the need for dynamic hardness testing of materials for correlation with wear and described two such devices, one termed the "Rota-Tester", and the other the "Vibro-Tester".

H. Blok ("War on Wear") presented a philosophical discussion of wear which he defined as follows: "Wear is the undesirable migration of the material of a solid surface, essentially due to overstressing caused by mechanical forces, if these are exerted in a direct way on the surface by its continuous or repetitive motion relative to a fluid or solid in contact." He stated that the migration of surface material occurs mainly in two ways. The first is complete migration or removal of surface material; this is the most radical form. The second is partial migration of material which may take place in the form of either plastic deformation or rearrangement of atoms into new physical units (recrystallization) or into new chemical constituents. In the process of rearrangement physical aspects such as diffusion and mutual solubility, as well as diverse chemical aspects, may enter as factors implicit in the above definition of wear.

One common characteristic of all types of wear is the mechanical overstressing of the surface material. A rational method of classifying wear involves the different methods by which overstressing can be caused. Blok divides wear into two broad classes:

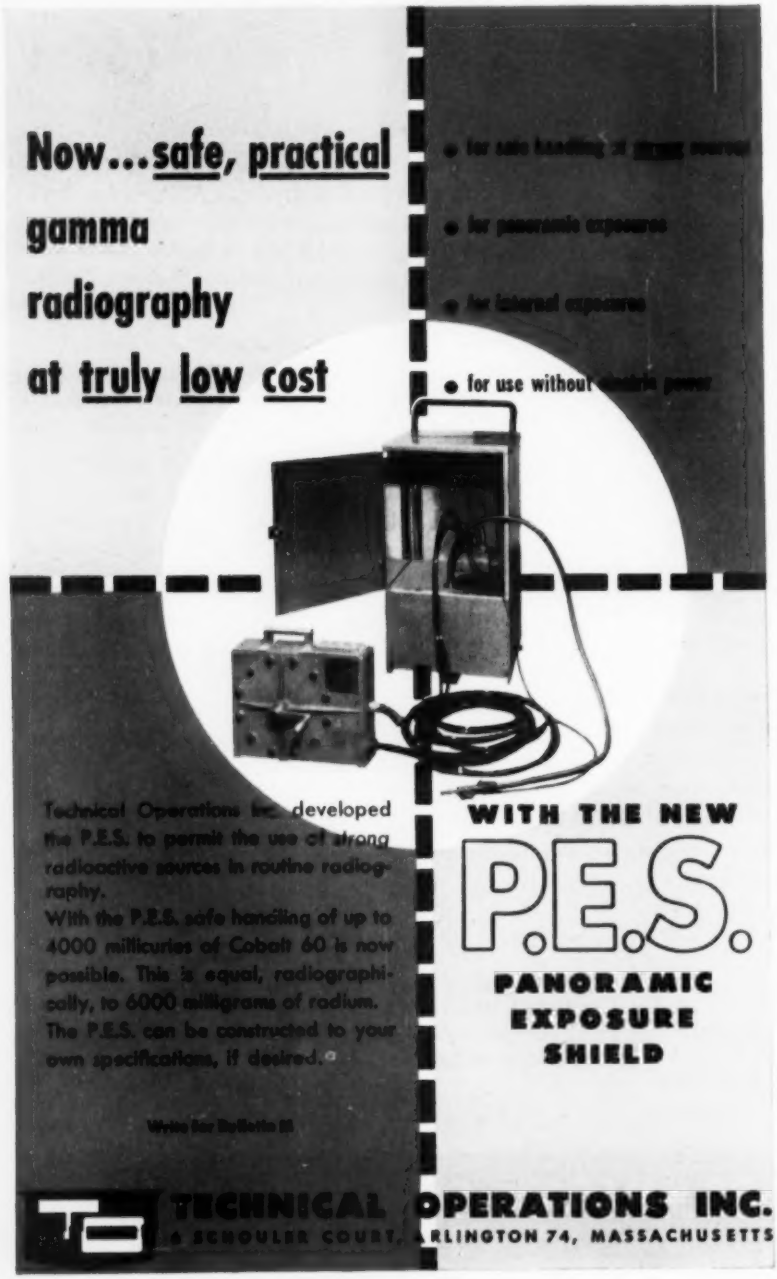
1. Single-sided wear (or erosion). This comprises cases where the contacting medium is a flowing liquid.
2. Double-sided wear. This is characteristized by the presence of two mating solid surfaces rubbing on each other.

One of the simplest types of double-sided wear is that characterized by the effects of frictional forces being negligible. The ensuing type of wear – pitting – thus is typical of rolling motion and, therefore, of concentrated contact; it follows that temperature rise by solid-frictional heat cannot be great.

More complex types of double-sided wear are those caused by abrasion and adhesion. Abrasive wear is defined as that type of double-sided wear in which the interaction be-

(Continued on p. 164)

*Digest of "Proceedings of the International Symposium on Abrasion and Wear", *Engineering*, Vol. 172, 1951, Aug. 24, p. 243; Nov. 30, p. 694; Dec. 7, p. 724; Dec. 14, p. 758; Dec. 21, p. 790; Dec. 28, p. 818.



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Wear and Abrasion . . .

(Continued from p. 162)

tween the mating surfaces is caused primarily by their geometric interference. This may be either macro or micro-abrasion. The former stops when the mating surfaces have been worn-in; the latter may be diminished by careful finishing.

Erosive abrasion accompanies any type of double-sided wear in which particles are detached from the surface, or if hard foreign particles find their way between the mating surfaces. Adhesive wear is characterized by an intense interaction between the two mating surfaces, namely, by their mutual adhesion in the contact areas.

The three general principles of combating wear are *(a)* the provision of protective layers, *(b)* conversion, and *(c)* diversion of wear attack. Protective layers may be formed by oxidation or by an interaction between lubricant and the rubbing surfaces. Boundary layers lose their efficiency at some characteristic breakdown temperature, although a low yield strength of the layers in their solid state appears to be conducive to low friction. Special examples of such protective layers are those applied artificially prior to service. Conversion of wear attack is the conversion of a destructive into a permissible type of wear. Diversion is defined as diverting the wear attack from the surface that is economically more vulnerable to the other mating surface that can be replaced at less cost. In the discussion, P. Grodzinski described a special type of abrasion test, using an instrument called "Micro-Abrasiontester".

J. M. Broeze ("Chemical Causes of Wear") noted that wear may be purely mechanical, often it may be termed physical, and frequently it may be of a chemical nature. With the latter condition the surface is attacked by some outside agent and subsequently detached. He divided chemical wear into three groups: *(a)* general lubrication with chemical attack by the atmosphere; *(b)* engine and gear lubrication with chemical attack by lubricants; and *(c)* engine lubrication with chemical attack by combustion products. F. P. Bowden, in discussion, offered a plausible explanation for the often anomalous behavior of oxide films, postulating that when the oxide and base metal have similar mechanical properties, protection against wear is often effected, but that when the base metal is weaker than the oxide, deformation of the underlying metal causes rupture of the harder oxide film.

P. Braber and G. Salomon ("Methods of Testing Abrasion and Wear in the Netherlands") described the facilities available in the Netherlands for testing abrasion and wear of the following materials: rubbers, plastics, varnishes, fibers, textiles, leather, wood, building materials, paving bricks, and metals. Concerning the wear of metals, they believe that such problems cannot be solved readily by measurements on only one of the conventional types of abrasion machines. They state that for the time being, direct microscopic observations on the grain structure of metals, and conventional tests such as the measurement of microhardness, are used with some success in explaining practical wear problems. A general conclusion was that testing equipment should either reproduce service con-

(Continued on p. 166)

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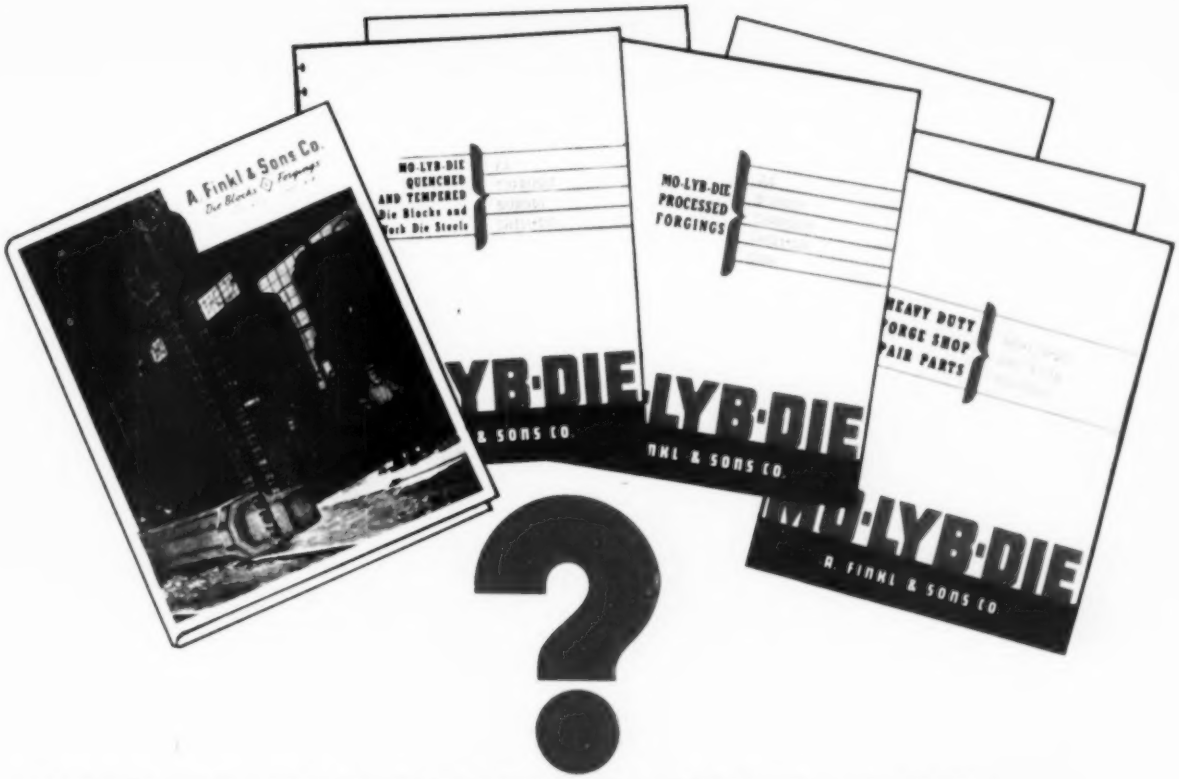
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Wear and Abrasion . . .

(Continued from p. 164)

ditions or permit the determination of a well-defined physical quantity.

H. C. J. de Decker ("Survey of the International Symposium on Abrasion and Wear") reviewed much of the information presented. He listed four factors that promote wear:

1. Mechanical attack caused by impingement, impact pitting, interlocking and adhesion.
2. Chemical attack, including oxidation and ozone cracking.
3. Fatigue phenomena.
4. Heating.

It is important to note that these factors rarely operate separately, because practically always more than one are present. The complexity of wear phenomena and the difficulties in studying them are largely due to the fact that the basic factors are always operating in groups and not separately.

Among the factors that counteract wear, he cited:

1. Reduction of wearing forces, either chemical or mechanical.
2. Choice of materials to resist mechanical or chemical influences.
3. Improvement in the finishes of surfaces.

Item 1 can be obtained by protective or lubricating coatings. Item 2 pertaining to mechanical forces is not only a question of hardness or modulus, but is often a question of tear strength and fatigue strength. For item 2 relative to chemical influences, although most frequently the resistance to oxygen is most important, resistance to other compounds is often necessary. The surface finish (item 3) must be of a type that is least exposed to mechanical forces; that is, it must be smooth.

In the ideal development of wear research, de Decker indicates the five following steps:

Registration and evaluation of practical wear processes.

Verification of rules and empirical formulas for the progress of wear.

Research for elementary processes that are the basis of the rules and formulas just mentioned.

Construction of a complete picture of wear from the elementary processes found.

Introduction of wear rating numbers to characterize wear processes.

S. J. ROSENBERG

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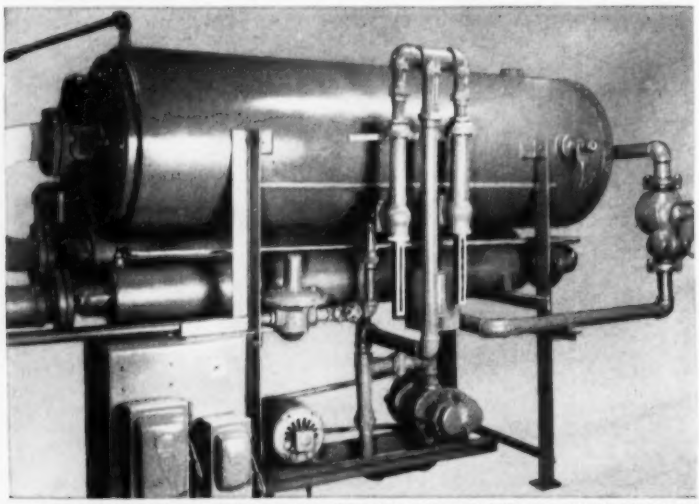

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Strain Markings in Aluminum Alloys*

WHEN SHEET is stretched as during straightening, or is deep drawn or formed, surface markings of two distinct kinds often appear. One of these kinds is variously described as Lüder's lines, stretcher-strain markings, flamboyant wedge-type markings or random markings (the surface indications of solid, slightly tapered blocks or bands which extend through the thickness of the sheet occurring just as the yield point is exceeded). The other kind occurs as parallel banding or low-intensity markings, which appear as a series of parallel lines extending across the sheet at a nearly constant angle to the direction of applied stress and which may be observed up to the point of fracture in the material.

It has been shown for mild steels that trace amounts of carbon, intensified by the presence of nitrogen, completely change the mode of

(Continued on p. 168)

*Digest of "The Influence of Composition on the Incidence of Strain Markings in Aluminum Alloys", by W. H. L. Hooper, *Journal* of the Institute of Metals, Vol. 81, 1952-53.

Mixing bowls made of Crucible stainless steel by American Car and Foundry Company, at its Milton, Pennsylvania plant.

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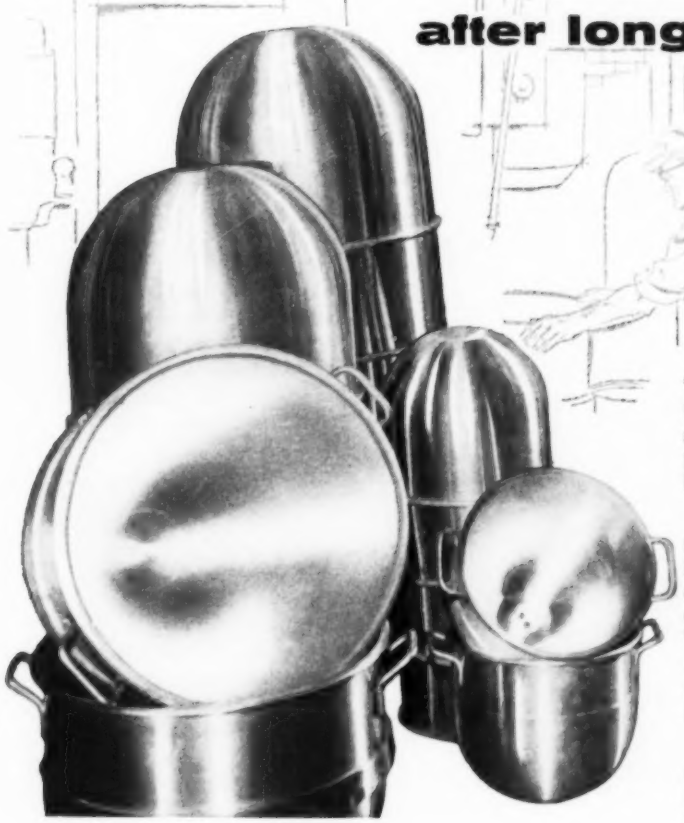

The fact is stainless steel improves with wear, for the more it is used the harder and smoother the surface becomes. And there is never any surface plating to wear on a stainless product, for stainless steel is *stainless* all the way through.

Yes, Rezistal® stainless is a *natural* for products that must take long hard service, or that must resist corrosion or wear, or stand up under daily cleaning with strong detergents. Take, for example, the stainless mixing bowls shown. They'll give many years of trouble-free service. And their smooth, sanitary surface makes them especially suited to the processing of baked goods, candy, cosmetics or chemicals.

Be sure you take advantage of all the money- and time-saving qualities of stainless steel. And be sure you specify Crucible stainless . . . made by the country's leading producer of special purpose steels. You'll get fast delivery of the grade and size you need when you call Crucible.

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Strain Markings . . .

(Continued from p. 166)

deformation of pure iron during stressing by causing a sharp yield point accompanied by the formation of strain bands. These same steels also exhibit strain aging effects whereas pure iron does not; the fact that titanium, which has a strong affinity for carbon, reduces this effect strongly supports the hypothesis that the phenomenon is associated with a supersaturated phase and that a sharp yielding, rather than uniform deformation, is caused by an atomic rearrangement.

Aluminum of 99.996% purity normally has a smooth stress-strain curve, but the addition of copper will cause steps to appear in the curve. Although other aluminum alloys show this effect to varying degrees, those of the binary aluminum-magnesium series are particularly prone to stretcher-strain effects. There would thus appear to be an analogy between the behavior in strain of mild steel and those industrial aluminum-magnesium alloys whose magnesium content exceeds the equilibrium solid solution limit at room temperature.

The investigation reported in this paper was carried out on a series of compositions ranging in magnesium content from 0 to 6% alloyed with aluminum both of high purity and of commercial grade. The objective was to separate the effect of impurities normally present in industrial alloys and to determine the relationship between intensity of marking and magnesium content. Earlier work had established the fact that stretcher-strain markings are developed in sheet only with a mean grain size of less than 0.05 mm., so grain refiners had to be added to the high-purity alloys. Small additions of chromium, manganese and titanium were used because these had previously been found to have no significant effect on the stretching characteristics of pure aluminum. Several other commercial alloys similar in composition to the American alloys 3 S, 17 S, 51 S and 75 S, were also included in the series.

Observations of the annealed binary aluminum-magnesium alloys revealed no markings, even up to 5% extensions on the alloys containing less than 0.6% magnesium. For the 0.9% magnesium alloy there were slight random markings at extensions of 0 to 2%, and slight parallel bands when stretched 5%. Beyond this composition limit all the alloys up to 6% magnesium showed a very pronounced effect of severe random markings at the low strain values and parallel banding at 5% strain.

Unalloyed aluminum and the aluminum-manganese (3 S type) were free from any marking effects for all extensions.

Of the heat treatable alloys, the aluminum-magnesium-silicon (51 S type) showed no markings in the annealed condition, slight parallel bands at 0 to 2% strain after solution heat treatment, and none after both a solution and aging treatment.

The aluminum-copper-magnesium-zinc alloy (75 S type) showed no markings at 0 to 2% extension. Annealed aluminum-copper-magnesium (17 S type) showed no markings at 0 to 2% extension, but random markings appeared on alloys that had received a variety of slow quenches from temperatures of 750 to 840° F., or when tested immediately from a solution heat treatment of 925° F.; however, after aging seven days at room temperature the random markings were only slight.

The occurrence of random markings in solution treated and quenched aluminum-copper-magnesium alloy sheet appears, upon first consideration, to be anomalous since in aluminum-magnesium alloys random mark-

(Continued on p. 170)

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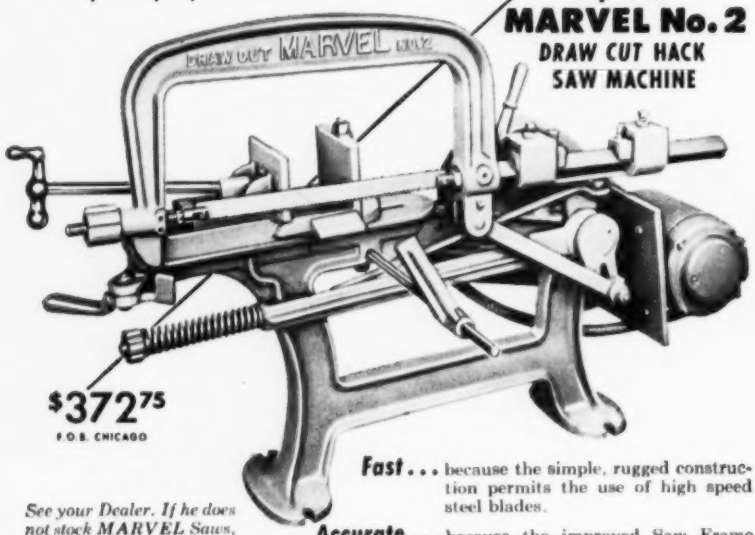

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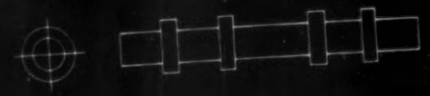

Turning

Tool tips on multiple-tool setup, turning SAE 1050 axles in as-forged condition. Best competitive steel: 6 to 7 axles per grind per set. VASCO SUPREME gives 15 axles per grind per set of tools on same job.

Boring

Boring bits, on axle hole of SAE 1060 car wheels, as forged, hardness BHN 255. Competitive steels gave 20 wheels per grind. VASCO SUPREME averages 40 wheels per grind on this assignment.

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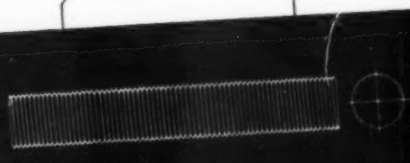
Milling

Shell end mills, on 30″ diameter cams for carpet looms. Regular high speed steels produced 6 cams on first grind—gave 1 to 2 regrinds. VASCO SUPREME produces 14 cams on first grind, permits 3 regrinds before too small.



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These instances of SUPREME cutting efficiency, taken at random from current report files, typify the unparalleled service to industry provided by this extraordinary High Speed Steel. VASCO SUPREME will do work no other high speed steel will do. It is often used with cemented carbide tools—and at far less cost. And there are applications where *only* VASCO SUPREME's unique combination of strength and toughness will do the job as it should be done. *Write us about your present needs.*

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Strain Markings . . .

(Continued from p. 168)

ings can be avoided by quenching from comparable temperatures. The conclusion that this effect is associated with internal stresses receives some support from the observation that the markings were more intense with less drastic quenching. Aging at 330° F. completely removed any tendency to strain marking, a result which might be related to the removal of magnesium from solid solution by the precipitation of a magnesium-rich phase.

Both aluminum-magnesium and aluminum-copper-magnesium alloys, in the physical condition in which strain marking is developed on stretching, are supersaturated in respect of solute elements or compounds. In both types of alloys, moreover, some decomposition of the solid solution is known to be induced by straining. The analogy with mild steel, therefore, appears to be close, and current theories associating strain markings with atomic movements in the lattice analogous to those experienced in precipitation hardening receive further support.

G. M. YOUNG

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Welding of Binary Titanium Alloys*

THIS PAPER summarizes the most comprehensive work done to date on the welding of two-phase titanium alloys. The work was conducted at Battelle Memorial Institute under the sponsorship of the Watertown Arsenal Laboratory, and is concerned with the mechanical and metallurgical characteristics of arc welds of binary titanium alloys of iron, manganese, chromium and molybdenum. The compositions selected for study generally covered the entire two-phase field for each binary system.

Welds were produced in several thicknesses of plate by tungsten-arc welding in a special airtight welding chamber under an atmosphere of helium. The resultant welds were evaluated by tensile, bend, hardness and impact tests as well as by metallographic examination.

The value of post weld heat treatment was assessed in a preliminary way. The treatments were selected to reduce transformation hardening and to obtain maximum ductility. These treatments included:

1. An alpha-beta heat treatment. This consisted of heating the specimens to 1350° F., furnace cooling at a rate of approximately 3° per min. to 1150° F., and water quenching.

2. A beta-quench heat treatment was accomplished by heating the specimens into the beta field and water quenching.

3. A beta-anneal heat treatment, which consisted of heating the specimens into the beta field and furnace cooling.

The most striking feature of the results obtained was the similarity of the various alloy systems. This has been discussed previously in "The ABC of Titanium Alloys" (*Metal Progress*, November 1952) and is

(Continued on p. 172)

*Digest of "The Effect of Alloying Elements on Welds in Titanium", by G. E. Faulkner, G. B. Grable and C. B. Voldrich, *Welding Research Supplement*, Vol. 18, October 1953, p. 481s-497s.

Tool Steel Topics

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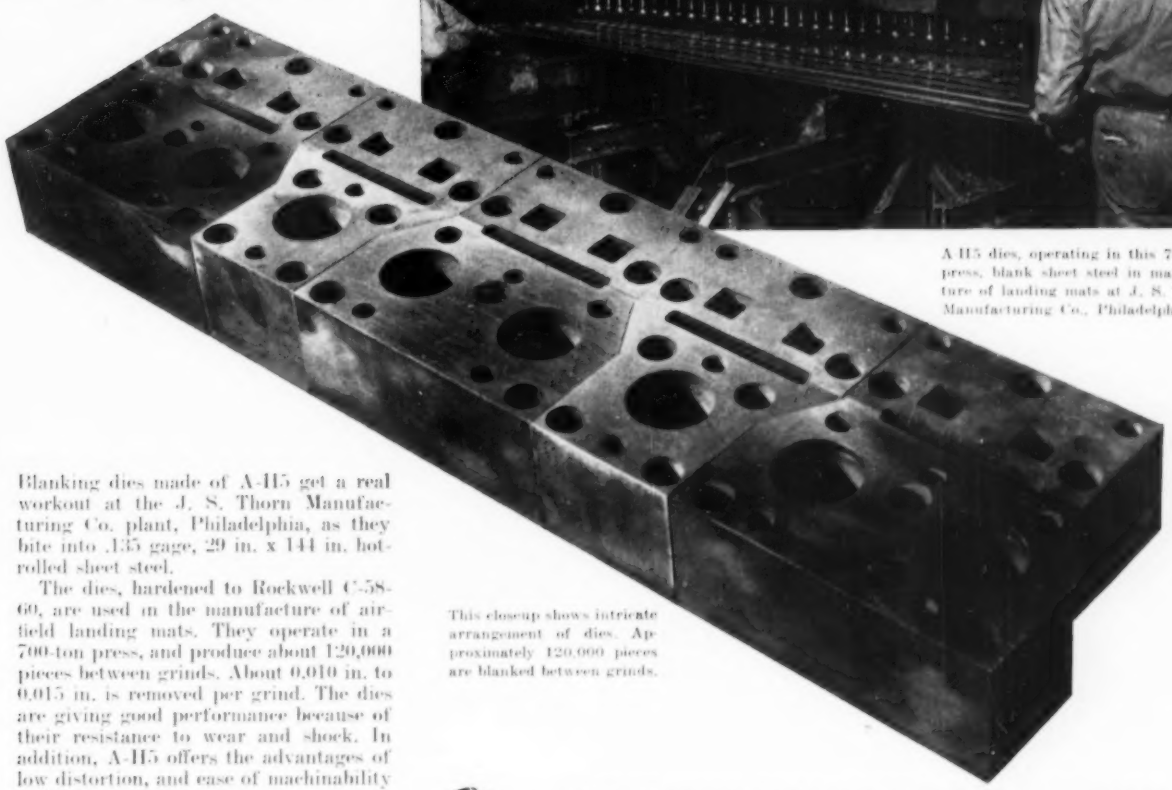
Dies of A-H5 Give Good Service in Turning Out Landing Mats

A-H5 dies, operating in this 700-ton press, blank sheet steel in manufacture of landing mats at J. S. Thorn Manufacturing Co., Philadelphia.



This closeup shows intricate arrangement of dies. Approximately 120,000 pieces are blanked between grinds.

Blanking dies made of A-H5 get a real workout at the J. S. Thorn Manufacturing Co. plant, Philadelphia, as they bite into .135 gage, 29 in. x 144 in. hot-rolled sheet steel.

The dies, hardened to Rockwell C-58-60, are used in the manufacture of air-field landing mats. They operate in a 700-ton press, and produce about 120,000 pieces between grinds. About 0.010 in. to 0.015 in. is removed per grind. The dies are giving good performance because of their resistance to wear and shock. In addition, A-H5 offers the advantages of low distortion, and ease of machinability and heat treatment.

A-H5 is our 5-pct-chrome air-hardening tool steel. It's an easy tool steel to machine, too, as it can be annealed to 212 Brinell.

Typical Analysis

Carbon	1.00	Molybdenum	1.10
Manganese	0.60	Vanadium	0.25
		Chromium	5.25

A-H5 is an economical steel for dies, punches, and forming and blanking tools. It is well liked wherever safe hardening, low distortion and increased resistance to wear are required. Why not give it a trial? Your nearest Bethlehem tool-steel distributor can supply you promptly.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Avoid Premature Failure—Don't Make Shock Tools Too Hard

As a rule, shock-resisting tool steels perform best when they are hardened to Rockwell C-55/C-60. At such a range, there's a good compromise provided between toughness and resistance to wear. When premature failure occurs in these grades, it can usually be traced to excessively high hardness.

But rather than harden shock-resisting steels to Rockwell C-59 or higher, when such hardnesses are required, it would be better to select a carbon tool steel.

When greater wear-resistance is required, the chrome-tungsten grades of shock-resisting tool steel may be carburized to provide a hard case and a shock-resisting core. The carburized case used for this type of shock-resisting steel should be only 0.010 deep. This method can be used to good advantage when you are manufacturing such items as reamers, swaging dies and master hobs.

Welding Titanium . . .

(Continued from p. 170)

well illustrated in this current paper. In almost all tests, for any given strength level, the tensile ductilities, weld bend ductilities and impact values were similar, irrespective of alloy system. The single exception was found in the impact values for the welds in the iron alloys, which were somewhat low.

The tensile tests made on the welded joints failed almost exclusively in the parent metal, indicating that the weld metal and heat affected zones had higher strength than the base metal.

Bend ductility results are illustrated in Fig. 1 and 2 which show the general loss in bend ductility with increasing alloy content for the base material and the rather precipitous loss in ductility in the weld samples. The bend ductility was measured by placing a grid on the bend specimens and measuring elongation over a ½-in. gage length. In practically all cases the weld bend ductility approached zero when the strength level of the base material exceeded 120,000 psi. The single exception was the weld made with 13% Cr in ½-in. plate. This was ductile in the as-welded condition but brittle after heat treatment (beta quench).

The notched-bar impact results for the weld metal correlated fairly well with bend ductility. With the exception of the iron alloys, all alloys which had fair bend ductility also showed good notch toughness. As with bend ductility, alloys with greater than 120,000 psi. ultimate showed poor notch-impact values.

The hardness studies showed that for the majority of alloys the weld metal and heat affected zones were considerably harder than the base metal. This is the result of heating the material high into the beta field during welding and rapidly cooling. After heat treatment hardness of weld metal, heat-affected zone and base metal was generally similar, although the weld ductility was not restored.

The microstructure observed in the weld metal and heat-affected zones changed considerable as the alloy content increased. In the low alloys (0 to 3% alloy content) acicular-type structures were observed, which were coarsened slightly on heat treatment. All welds with this structure were ductile. The intermediate alloys (3½ to 6% alloy content) produced as-welded structures which consisted of a fine dispersion of alpha in a beta matrix. Heat treat-

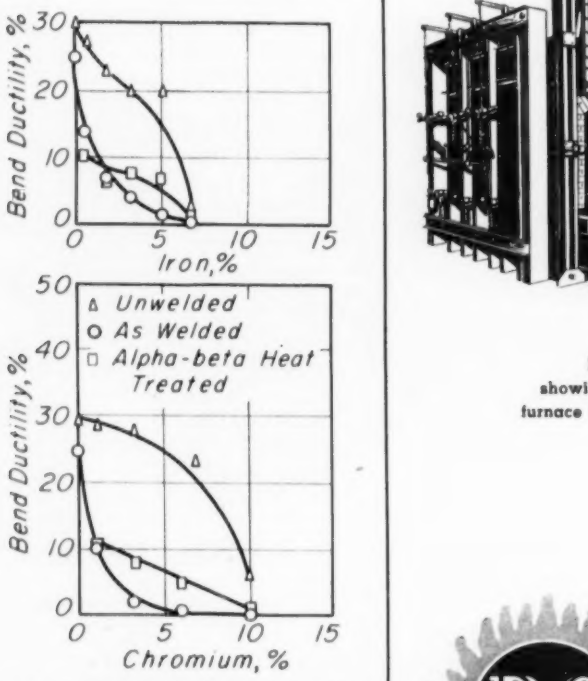
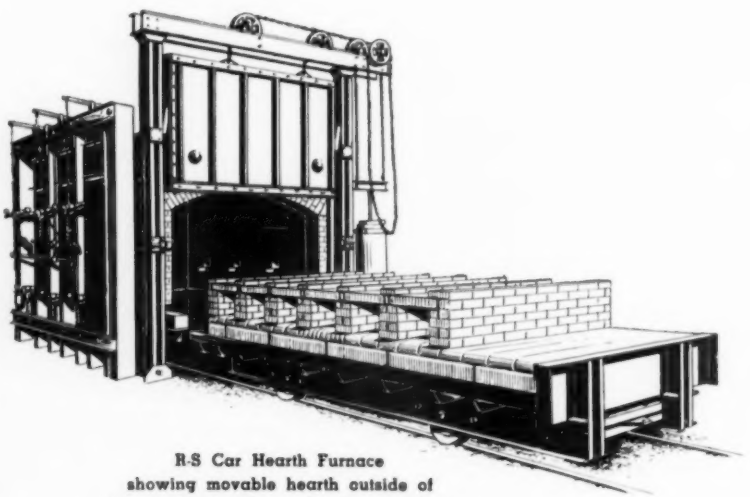


Fig. 1 — Longitudinal Bend Ductility of Welded and Unwelded ¾-In. Titanium Plates Alloyed With Iron and With Chromium. Alloy with 10% chormium was given beta anneal instead of alpha-beta heat treatment



R-S Car Hearth Furnace showing movable hearth outside of furnace for loading of heavy materials.

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ment resulted in the precipitation of more Widmanstatten alpha and some improvement in weld ductility. The high alloys (above 7% alloy content) generally produced a retained beta structure with an intergranular alpha network. Heat treatment caused the formation of alpha in the beta matrix but did not improve ductility, probably because of the grain boundary network which was still present.

The authors summarize their results as follows:

The bend ductility of welds in the alpha-beta alloys decreased rapidly with increasing alloy content, becoming very low when the alloy content approached 3 to 6%.

Post weld heat treatments designed to minimize transformation hardening and to stabilize the alloys may generally be used to improve the bend ductility of welds in alloys having up to 6% alloy content. Weld embrittlement in alloys containing up to 6% alloy content appeared to be correlated with transformation hardening.

Welds with very good bend ductility in the as-welded condition were made in the 13% metastable-beta chromium alloy, but the welds were embrittled by heat treatment. Welds in the other high alpha-beta and metastable-beta alloys had very low ductility in both the as-welded and heat treated conditions. Since the hardness of the weld metals and heat-affected zones approached that of the base metals after heat treatment, it appeared that factors such as freezing segregation, cast structure or contamination may have contributed also to weld embrittlement.

The notch toughness at room temperature of the base metals and ductile weld metals was relatively good for the low and intermediate alloys in all but the iron series. The notch toughness of the base metals and ductile weld metals was relatively good at −40° F. for the low alloys and some of the intermediate alloys.

Transformation hardening was observed in the weld metals and heat-affected zones of the welded joints in most of the alloys. It is caused by the structural changes which occur when these zones are heated into the beta field and rapidly cooled during the welding operation. Transformation hardening increased with increasing alloy content in the low and intermediate alloys, reached a maximum in either the intermediate or high alpha-beta alloys, and with the exception of the iron alloy, decreased considerably for the metastable-beta alloys. Transformation hardening became practically negligible in the 15% manganese and 13% chromium alloys.

D. R. Luster

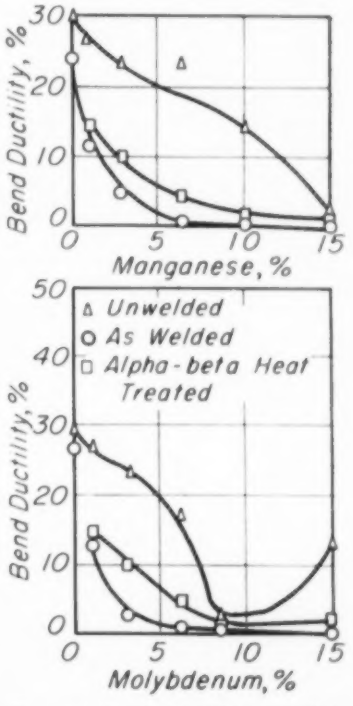

Fig. 2 – Bend Ductility of Plates Alloyed With Mn and Mo. Alloy with 15% Mo was given beta quench

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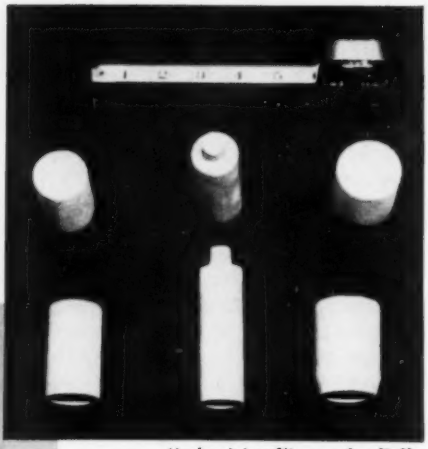

Carburizing Fixture for Ball Bearings 1½" diameter—Analysis 35% Ni — 15% Cr

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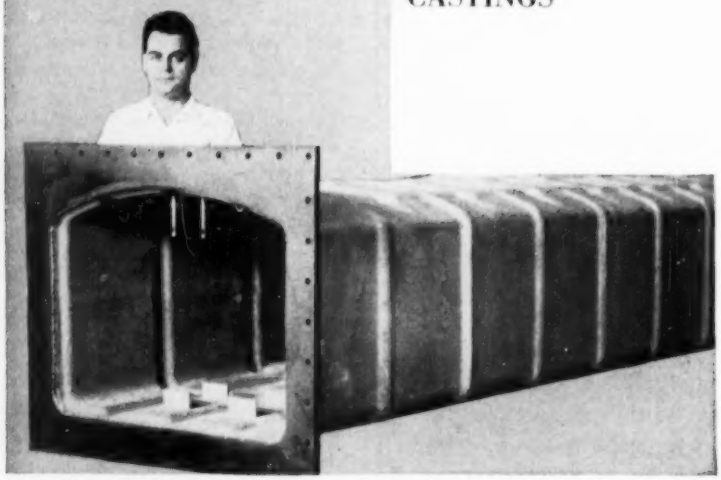

Muffle for Continuous Strip Annealing 12' 6" long — Analysis 38% Ni — 18% Cr.

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Comparison of Costs in Openhearth and Electric Furnace Shops*

THIS REPORT presents a detailed study of the comparative cost and operating features of modern openhearth furnaces and electric furnaces of equal output. Consideration is given to :

1. Space requirements of equivalent plants.
2. Investment costs of plants.
3. Cost of materials in the charge.
4. Operating cost above per ton of ingots.
5. Ingot yield.
6. Furnace availability.

The report presents specific information regarding plants of the two types with annual output of 250,000 tons, 500,000 tons and 1,000,000 tons. Since the unit of 1,000,000 tons has been used as a yardstick in other reports and discussions, this review will be confined to this output. The report also includes comparative figures for the melting of 100% cold charge and melts comprising 50% hot metal and 50% scrap in both types of furnaces.

The space required for an electric furnace plant with an output of 500,000 tons per year is estimated at 126,000 sq.ft. as compared to an openhearth plant of the same output with the required space of 156,000 sq. ft. Another comparison of this item is presented in reference to the Fairless Works of the U.S. Steel Corp., the latest openhearth plant built. In this plant, with a capacity of 1,800,000 tons of ingots, the total space is 333,567 sq.ft. A modern electric furnace shop with the same annual tonnage would require 13 arc furnaces 20 ft. in diameter, and a total space of 230,000 sq.ft. or about 70% of that required for the openhearth shop. In estimating these specific requirements, the authors assume that the large electric furnaces operating

(Continued on p. 176)

*First of a three-part digest of "Comparative Economics of Openhearth and Electric Furnaces for Production of Low-Carbon Steel"; a report prepared by S. L. Case, D. D. Moore, C. E. Sims and R. J. Lund, Battelle Memorial Institute, of a study sponsored by the Electric Furnace Survey Group and Bituminous Coal Research, Inc. Published by Bituminous Coal Research, Inc., Pittsburgh; price $10.

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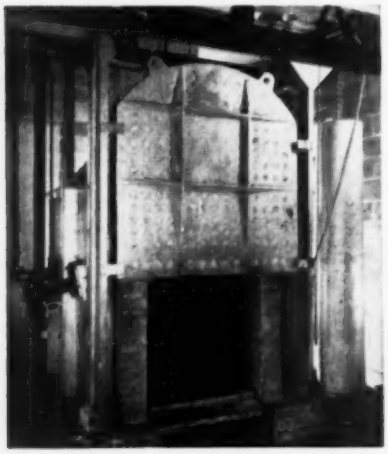
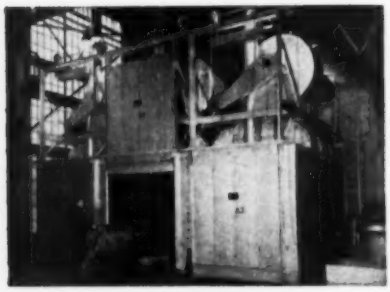


This car-type annealing furnace is an example of the heat treating furnaces designed and engineered by the Carl-Mayer Corp. This particular car bottom furnace was designed for the heat treatment of chain up to 2000°F. at Cleveland Chain & Mfg. Co. We also build furnaces for other uses, including aluminum and magnesium heat treating.

● ● ●



This battery of three aging ovens incorporates direct gas-fired recirculating air heating systems and other features which contribute to uniformity and faster, more economical production in a large aluminum company.

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Cost Comparison . . .

(Continued from p. 174)

on a single slag practice would produce more than 20 tons per hr. in a 20-ft. furnace. An openhearth plant would require 250-ton units which, using a 50% hot metal charge, could produce 20 tons per hr. The furnace availability of the electric furnace is set at 95% and the furnace availability of the openhearth furnace at 92%. An ingot yield of 87% is estimated for both types of furnaces in producing a given type of steel.

Increasing the size of the electric furnace above 20 ft. diameter would greatly increase the hourly output; it is stated that a 24-ft. diameter arc furnace would produce 31.7 tons per hr. if the transformer capacity were raised to 35,000 kva. On the other hand, increasing the size of the openhearth furnace above 250 tons capacity has very little influence in increasing its hourly output. The use of the larger electric furnaces would considerably decrease the space requirements and also reduce the capital investment cost below that given in Table I.

A complete appraisal of the material and heat balance in the openhearth and electric furnaces is covered in the next section of the report. The materials required for the openhearth furnace are approximately 6000 lb. per ton of ingot as compared to 2330 lb. per ton of ingot for the electric furnaces. The main difference in the material charges is in the 3000 lb. of air required for fuel combustion in the openhearth.

A large openhearth furnace operating on a 50% hot metal charge is estimated to absorb a heat input of 4,776,000 Btu. as compared to a heat input of 621 kw-hr. (2,120,000 Btu.) for the electric furnace. The thermal efficiency of the electric furnace is obviously very much greater, since 79% of the heat in the power supplied is contained as heat content of the liquid steel. In the openhearth only 37% of the heat in the fuel is contained in the liquid steel.

The investment cost of comparable openhearth and electric furnace plants is greatly in favor of the electric shop. The total capital cost of an openhearth shop of one million tons capacity is given as $26,656,000. An electric furnace plant of similar output costs only $15,900,000. These are so significant that a comparative tabulation for the two plants of one million tons is made in Table I.

The estimate is probably based on the 50% hot metal charge, even though the authors admit that there is no established experience for the operation of large electric furnaces on a 50% hot metal charge. It should be emphasized that the discussion of capital investment cost only covers the steel melting facilities and does not include many other items such as land, roads, offices, power plants, shops, and numerous other auxiliaries which are common to both types of plant.

(To be continued.)

E. C. Wright

Table I — Estimated Capital Cost for Melting Shops of 1,000,000 Tons Annual Ingot Capacity

(Estimates Based on 1952 Price Levels)

Items	Openhearth	Electric
Buildings and foundations	$ 8,000,000	$ 3,500,000
Furnaces and auxiliary equipment	6,000,000 (*a*)	4,000,000 (*b*)
Handling Equipment for scrap and melt	3,000,000 (*c*)	1,750,000 (*d*)
Pit-side equipment	3,250,000	2,750,000
Stripper facilities	2,100,000	1,750,000
Molds and mold-conditioning plant	1,250,000	1,000,000
Storage facilities	550,000 (*e*)	400,000 (*e*)
Utilities	2,500,000 (*f*)	750,000 (*g*)
Total	$26,650,000	$15,900,000

(*a*) Eight 200-ton furnaces; fuel lines, pumps, stacks, etc.
(*b*) Eight 20-ft. furnaces with 25,000-kva. transformers.
(*c*) Hot metal cars, charging machines and boxes, scrap-yard cranes.
(*d*) Bins, scrap-yard cranes, charging crane, charging machines.
(*e*) Refractories, oil, limestone, etc.
(*f*) Steam boilers, water pumps, power substation.
(*g*) Water, air, power lines.

Another first

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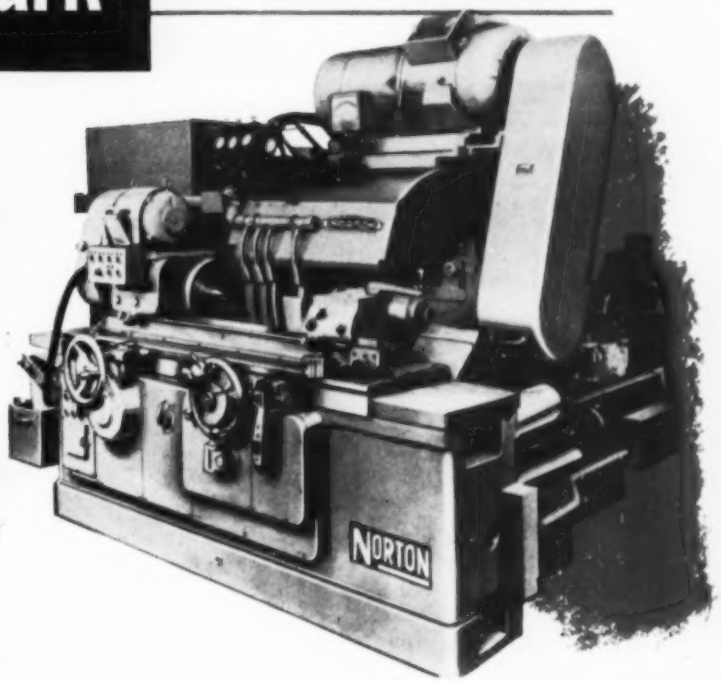

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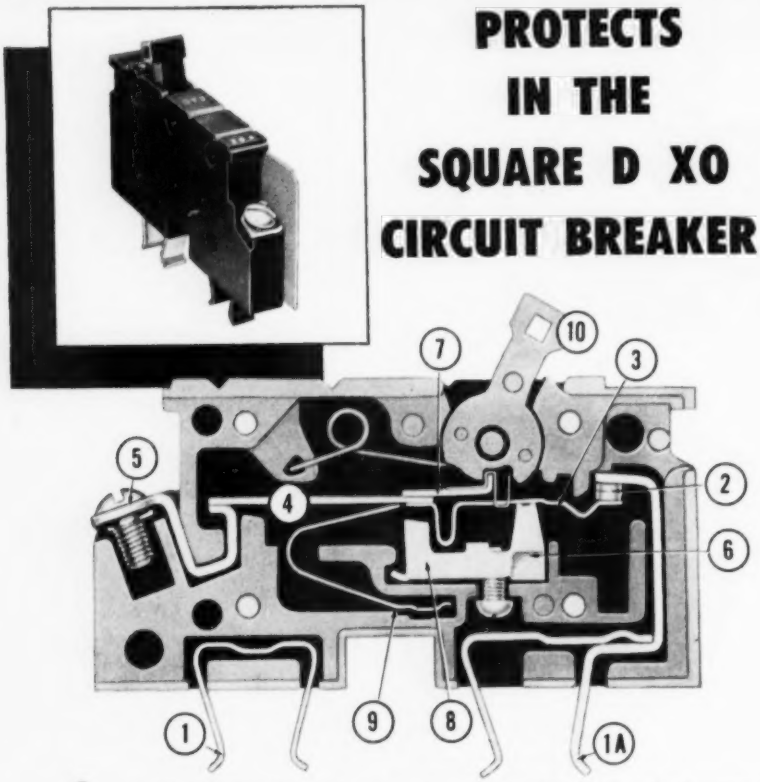

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As the thermostatic bimetal element (4) becomes heated by overload, it deflects downward but movement is restricted temporarily by the jaws of spring latch (6), through which it must pass. A heavy overload increases magnetism in armature (7) which is attracted to yoke (8) giving added force to breaking action. The Chace Thermostatic Bimetal element (9) compensates for ambient temperature in the installation. Spring loaded handle (10) moves to left to signal opening of circuit and locks breaker contacts in open position.

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Transgranular Stress-Corrosion*

THIS PAPER describes the results obtained in exposing stressed specimens of 21 different analyses of chromium-nickel steels to the corrosive effects of boiling chloride solution. Under these test conditions transgranular and brittle failures occurred in most of the samples. This kind of failure is common in stainless steel equipment and is in no way related to the better known intergranular failures which have been so thoroughly studied during the past 20 years.

Transgranular stress-corrosion has been reported for many types of alloys and in the studies of this kind of failure boiling magnesium chloride ($MgCl_2$) solutions have been used by numerous investigators. This reagent was used in much of the testing reported in this paper but transgranular cracking was also encountered with many of the other chloride solutions.

Most of the tests reported here were carried out by bending 18-gage strips, measuring ½ in. wide and 3 in. long, into a U shape. This was done with carefully cleaned and descaled strips by placing them across rollers between which a plunger was forced so that a standard and uniform bend was obtained on all test pieces. The bent specimens were immersed in 200 ml. of chloride solution contained in an 18-8 chromium-nickel stainless steel vessel and were insulated from the holder by glass slides between the wall of the vessel and the sample. Test periods extended from 2 to 1000 hr. and the samples were removed periodically for examination for cracks. The amount of stress in the bent specimens is not known, but it must be regarded as appreciably above the yield strength. (The stress value varies in different parts of the bent specimen.)

Highly reproducible results were obtained with the chromium-nickel alloy types studied, provided the specimens are examined frequently enough. In the tests using 42% $MgCl_2$ solution, the stainless steels of the

(Continued on p. 180)

*Digest of "Transgranular Stress-Corrosion in Chromium-Nickel Stainless Steels", by C. Edeleanu, *Journal* of the British Iron and Steel Institute, February 1953, Vol. 173, p. 140.

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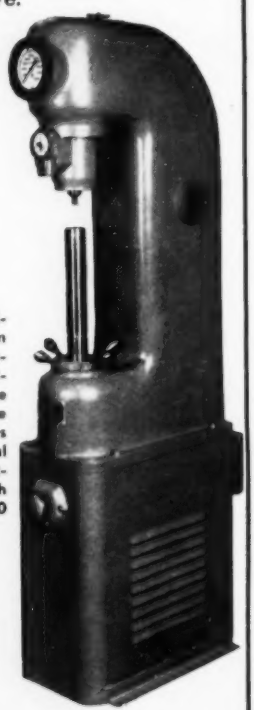

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Stress-Corrosion . . .

(Continued from p. 178)

chromium-nickel types 18-8, 18-8 with titanium, and 18-8 with molybdenum all failed within 2 hr.; 12-12 Cr-Ni alloys lasted 8 to 15 hr.; 25-20 Cr-Ni alloys developed cracks in 28 to 220 hr. The ferritic alloys such as 17% Cr, 2% Ni, and the straight chromium types containing 20, 17 and 13% Cr with carbon contents of 0.08 to 0.30% resisted cracking for exposures of 500 hr. In these, however, a pronounced general corrosion took place. The results demonstrated that the stainless steel alloys of the 18-8 type were very susceptible, the austenitic grades with higher nickel were much less susceptible, and the ferritic and martensitic chromium alloys were most immune to transgranular cracking under the conditions of test.

Based on the observation that the 18-8 type of alloy was the most susceptible to transgranular cracking, seven special melts with varying chromium and nickel were prepared and tested as follows:

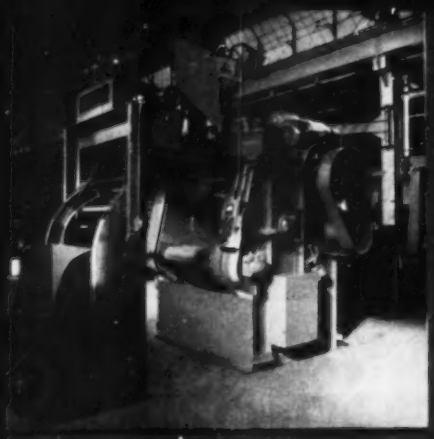
% Cr	% Ni	Time to Failure, Hr.
17.34	14.00	72 to 383
17.88	12.08	27 to 439
17.76	7.28	17 to 117
15.32	8.05	700*
19.82	8.15	5 to 462
15.27	12.00	7 to 71
19.88	12.10	3 to 414

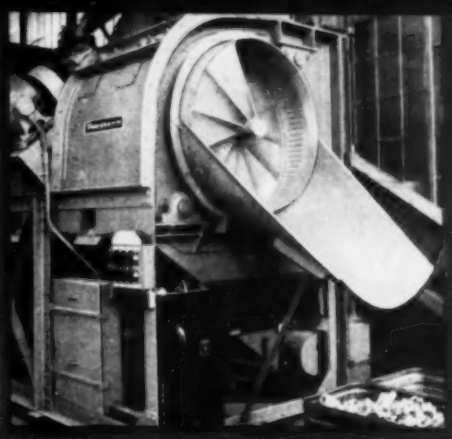
*No failure

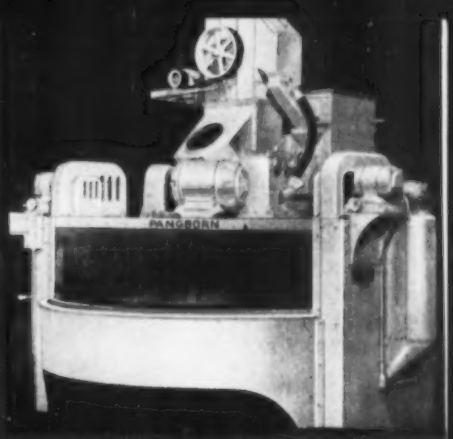
While all of these alloys were usually much less susceptible than the 18-8 type, the results are widely scattered. Another series of alloys of the 18-8 base type but with additions of 2% Cu, 5% Mn, and 0.11% nitrogen reacted much like the normal 18-8 types containing additions of either titanium or columbium, and the latter behaved similarly to the standard 18-8 alloy.

Although the preceding results were obtained with solutions containing 42% $MgCl_2$, many tests were made with chloride solutions of zinc, sodium, potassium, lithium, ammonium, tin, nickel, manganese, calcium, chromium and mercury. Strength of these varied from 20% concentrated to saturated. Only the alloys of the 18-8 type were tested in these solutions. Transgranular cracks resulted from all exposure

(Continued on p. 182)







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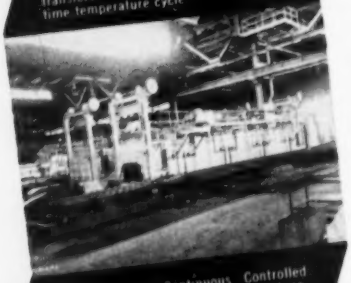

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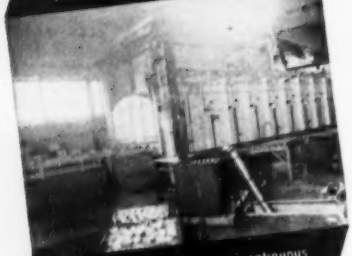

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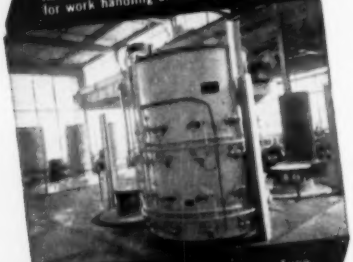

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Stress-Corrosion . . .

(Continued from p. 180)

tests but those with $CrCl_3$ and $HgCl_2$; in the latter very severe general corrosion stopped the tests after 30 to 100 hr. The extent of the damage caused by the solutions varied in severity; samples were broken after exposure of 3 to 4 hr. in $ZnCl_2$ and $CaCl_2$, nests of small cracks (fan-shaped) were developed by NaCl, KCl, LiCl and NH_4Cl, and small cracks appeared after 79 and 1216 hr. in $NiCl_2$ and $MnCl_2$, respectively. In another series of tests, U-shaped strips of several titanium and columbium-stabilized 18-8 alloys were bolted to a ¾-in. steel bar and placed in the steam line of a boiler operating at a steam temperature of 375° F. and a pressure of 175 lb. After 1300 hr. exposure all of these samples had very fine transgranular cracks.

Microscopic examination of the cracked specimens showed that the 18-8 alloys are not single-phase austenite after stressing. The metal contains a martensitic phase which is formed from the straining of metastable austenite. Since this basic 18-8 alloy is known to be of a borderline composition for stable austenite, the result is to be expected. Increasing the stability of the austenite by a higher nickel ratio, as in 20-20 Cr-Ni type, reduces the tendency for developing the "pseudo-martensite" upon cold straining and the susceptibility to transgranular cracking. The authors state that the corrosion is accelerated in the regions with the martensitic constituent, and the transgranular cracks occur along these paths. Both the delta phase and the ferrite phase are immune to transgranular attack, as are also the stable austenite structures found in the higher nickel alloys.

The present work supports the contention that the transgranular stress-corrosion of austenitic chromium-nickel steels is due to preferential attack on small quantities of quasi-martensite, which form in this type of steel on straining. The susceptibility can be reduced either by increasing the nickel content of the normal 18-8 stainless steels, and thus increasing the stability of the austenite, or by reducing the alloy content, thus producing a steel which contains large quantities of quasi-martensite

(Continued on p. 184)

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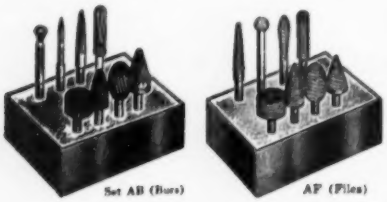

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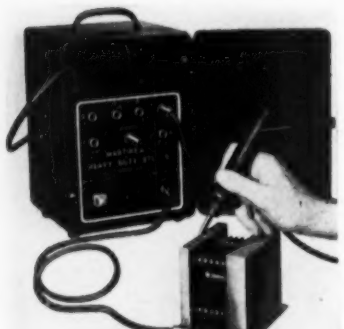

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Stress-Corrosion . . .

(Continued from p. 182)

and in which corrosion is more widely distributed. Increasing the chromium content also leads to some improvement, presumably because the austenite in the two-phase alloys produced in this manner is relatively stable at low temperatures.

Transgranular stress-corrosion can occur in many solutions containing chlorides, and oxidizing agents can accelerate failures. Impure steam may also cause stress-corrosion.

Annealing treatments should remove internal stresses below a value at which danger from stress-corrosion is great. E. C. WRIGHT

Brittle Fracture as a Function of Grain Size*

BRITTLE fracture as a function of grain size receives some careful consideration in this paper by Dr. Petch, whose previous studies are well known in ferrous metallurgy. The specimens, having contents varying from 0.03 to 0.155%, are unnotched tensile bars, ¼ in. diameter, fractured in liquid nitrogen. The fracture is measured as the cleavage strength σ_c. The grain size l varies from single crystals to 8000 grains per sq. mm., developed by heat treatment in vacuum utilizing temperatures up to 1050° C (1920° F.) and periods up to 24 hr. Treatments at higher temperatures were avoided because they frequently produced intercrystalline failures.

Care is taken for true axial loading, smooth surfaces, relief of machining stresses, and delicate extensometric measurements, the data being corrected to zero deformation using curves of McAdam, Geil, and Mebs. A quadratic relationship results:

$$\sigma_c = \sigma_o + kl^{-1/2}$$

A plot of lower yield point shows a similar relationship:

$$\sigma_{l.y.p.} = \sigma_o + k^{\circ}l^{-1/2}$$

The amount of plastic strain at fracture is found to increase with decreasing grain size and with decreasing strain hardening rates. The

(Continued on p. 186)

*Digest of "The Cleavage Strength of Polycrystals", by N. J. Petch, *Journal* of the Iron and Steel Institute, Vol. 174, May 1953, p. 25-28.

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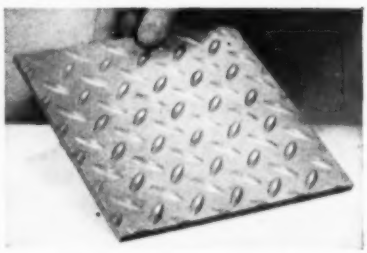

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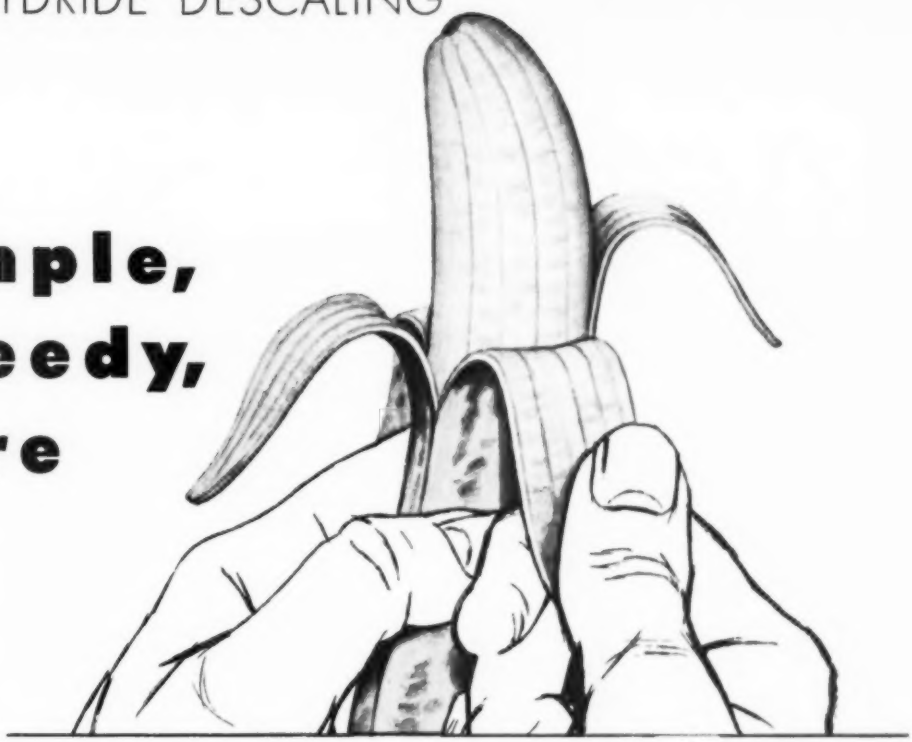

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Brittle Fracture . . .

(Continued from p. 184)

cleavage strength of polycrystalline specimens is found to be controlled by (*a*) the theoretical cleavage strength in the vicinity of the grain boundary, (*b*) by σ_{y_i} and (*c*) by grain size. Dr. Petch then develops a theoretical picture based upon dislocation theory and the assumption that Griffith cracks serve as the glide planes on which dislocation movement is blocked by the grain boundary. CARL A. ZAPFFE

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Higher temperatures are easily produced with the lamp by enclosing it in an oven consisting of a can having the same diameter as the lamp and a lining of two or three layers of household aluminum foil which is pierced to receive the specimen. With this enclosure for a 375-watt bulb, a 3-in. length of pipe of

(Continued on p. 188)

*Digest of "Radiant Heat for High Temperatures", by Carroll F. Powell, *Battelle Technical Review*, December 1953, p. 130-132.

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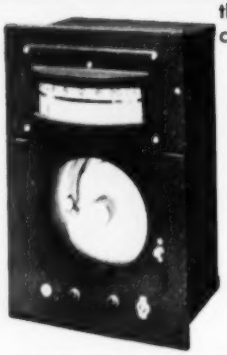

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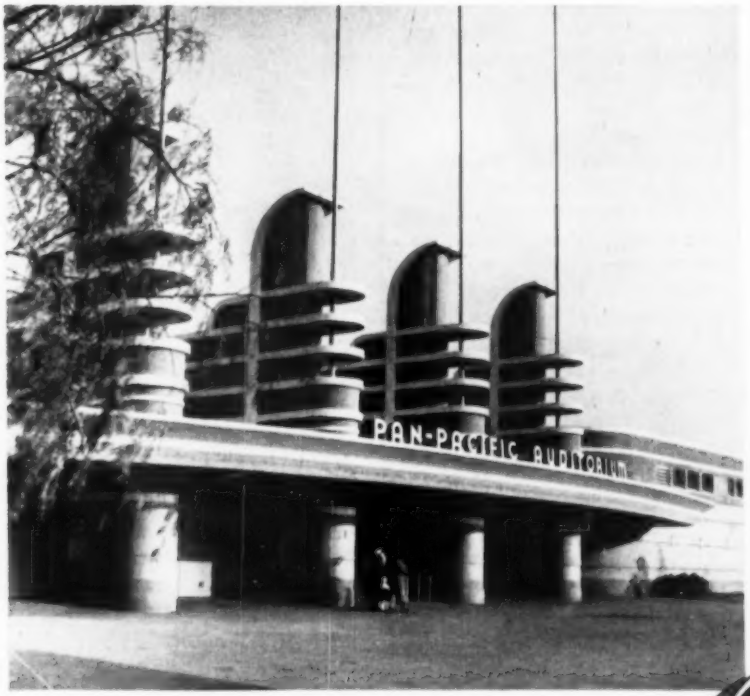

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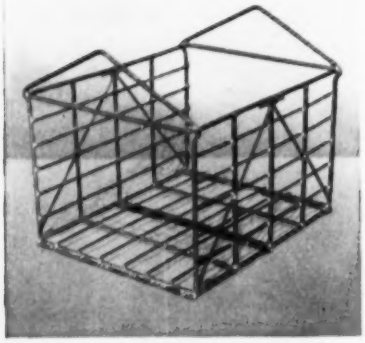

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Heat Lamps . . .

(Continued from p. 186)

1-in. diameter and ⅛-in. wall was heated to 1100° F. in 12 to 15 min. The temperature rise is rapid and 900° F. is reached in less than 7 min. The life of the lamp is long on a 100 to 110-volt supply, but only a few hours at 120 to 130 volts.

An improved type of reflector or "furnace" can be made easily and inexpensively by evaporating gold onto the inside of a pyrex beaker. Temperatures up to 1290° F. can be attained with it. A number of such units arranged in series could be used to form a cheap assembly line for heating small parts for soldering. It could also be used for heating nonconductive materials in vacuum. Such an arrangement would be both cheap and easy to maintain. A suitable type of lamp for this purpose has been developed by Sylvania Electric Products Corp. using a bulb of Vycor glass.

In order to obtain even higher temperatures an elipsoidal mirror has been used which focuses all the heat rays on a small area. With a 750-watt tungsten lamp in such a reflector, temperatures of 1800° F. have been obtained on a surface of 3 sq. cm.

J. B. WAGSTAFF

Silicon Monoxide Reactions in Steelmaking*

THIS INVESTIGATION describes three methods for determining the amount of silicon monoxide produced from mixtures of silicon and silica, and mixtures of hydrogen and silica, in the temperature region of 2370 to 3000° F. The thermodynamic properties of this compound in this temperature range are then deduced from the results.

Previous literature as to the nature and physical and thermodynamic properties of silicon monoxide exhibits considerable disagreement. This compound has been noted for several years in laboratory experi-

(Continued on p. 190)

*Digest of "Thermodynamic Properties of Silicon Monoxide", by N. C. Tombs, A. J. E. Welch, *Journal* of the Iron and Steel Institute, Vol. 172, September 1952, p. 69 to 78.

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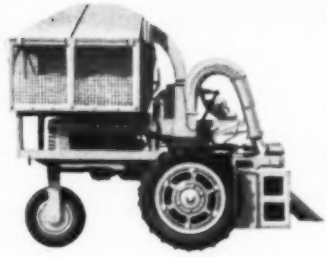

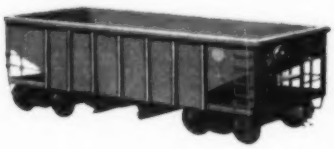

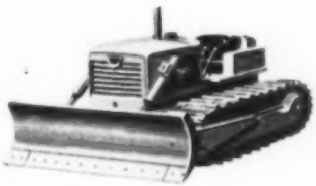

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Silicon Monoxide . . .

(Continued from p. 188)

mental work as a brown fume or as a black, vitreous, amorphous substance which sublimes in the furnace tubes after it is formed. Previous investigations have reported that this conforms to the stoichiometric ratio of the compound SiO, and X-ray examination of some of the deposits has confirmed this conclusion.

The study of the equilibrium

$$SiO_2 + Si \leftrightarrows 2SiO$$

was made by using the entrainment technique. This was done by heating mixtures of silica and silicon in a tubular furnace and passing purified argon gas over the mixture at temperatures between 2370 and 2730° F. A standard molybdenum wire-wound furnace protected by dry hydrogen was necessary in the temperature range of 2460 to 3000° F. The temperature of each run was controlled within 10° F. and the length of the entrainment runs varied from 2 to 9 hr. The argon gas used for entraining the silicon monoxide, which was volatilized, was carefully purified to remove all traces of water vapor, carbon dioxide and nitrogen. The purification train consisted of sulphuric acid, tubes of anhydrous magnesium perchlorate for moisture, plus tubes of potassium hydroxide for CO_2, and a special furnace containing a mixture of ignited calcium oxide and magnesium powder held at 1110° F. for removal of nitrogen. This removal was necessary to prevent formation of silicon nitride, and the purification procedure was very satisfactory.

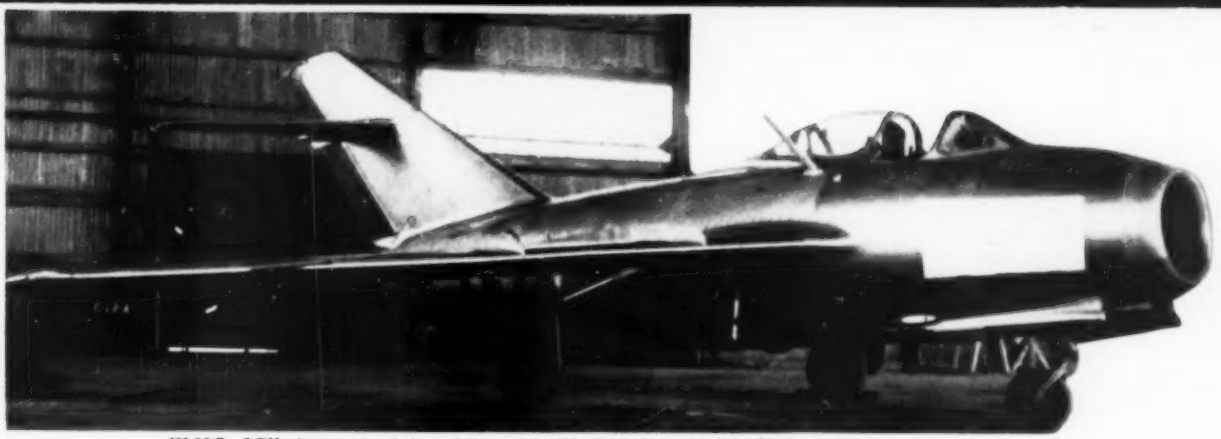
The silicon employed was normal lump grade crushed to 400 mesh in a rod mill and repeatedly extracted with hot HCl to remove all traces of iron. The silica was an amorphous product ignited at 212° F. for 24 hr. before use. This form was more reactive than crushed quartz.

The working tube of the reaction furnace was either of mullite or sintered alumina (Al_2O_3), the latter being much more satisfactory at the higher temperatures.

Two methods of measuring the entrainment of silicon monoxide in the argon gas were employed. In the first, loss of weight in the silica-silicon mixture was determined directly by weighing the boat contain-

(Continued on p. 192)

G·A ALLOYS THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION X-ite



"MIG 15" Russian jet fighter delivered to USAF in Korea by "tired" Communist*

THE MIG, we can knock it DOWN! But we shouldn't laugh it off!

IN January we inspected the Russian MIG-15 jet fighter delivered to U. N. Forces in Korea by a North Korean pilot.* He was "tired of Communism" and—probably a bit itchy before the gun sights of U. S. F-86 "Sabre Jet" pilots.

THE MIG is lighter and faster, can out-climb and out-maneuver the Sabre Jet at high altitudes, *but that isn't enough.* By April 10, 1953, the total of MIGs destroyed had risen to 611 against a loss of 54 F-86's. The score—11 to 1! F-86 pilots tell us that one MIG "kill" out of eight either came apart or lost control diving with F-86's on its tail.

THE North American F-86 is a ton heavier than the 14,000 pound MIG. It carries heavier armor. It has superior range at all altitudes, carries six 50 calibre machine guns, can carry two 1,000 ton bombs and sixteen 5 inch rockets, has est. 15 seconds of combat firing duration. The MIG carries two 23 mm. and one 37 mm. cannon, has larger projectiles with est. 6 seconds' firing duration, has better rate of climb, is faster above 27,000 feet and has about 10 percent higher "ceiling". MIG performance is improved by an est. 800 pound lighter engine with more "thrust".

THE MIG is inferior in details of craftsmanship and finish, such as flush rivets, corrosion-proofing, mating of components, etc. Bolts project through nuts from one-half thread to four. "Ours uniformly have two to two and one-half turns projecting. The Russkies use a lot less lengths and sizes"—said a Crewman—"The MIG engine is easier to service, as the fuselage separates at the motor mount.—Our job separates midway on the engine."

A NUMBER of MIG features noted were: (1) Light weight, welded thin sheet steel brackets of "beafing" ultra light aluminum structure and steel riveted through skins at junctures (welds *beneficially* not ground). (2) Brakes operated by an air cylinder. (3) Separate "low vulnerability" hydraulic system operates flaps. (4) The radio antenna is housed *flush* with the underwing surface (not in a hubble). (5) Ingenious detail in elevator controls, landing light fared in air-scoop, separable fastenings, etc. Stinko: MIG pilots must manually regulate cockpit pressurizing, F-86 is *automatic*.

LACK of service life and maintenance data, and of metal specs prevents engine evaluation. Much non-functional weight and finish has been eliminated. Color of turbine blade oxide indicates a probable minimum, or absence, of controversial Cobalt. Costly, questionable tolerance specs on "cold" turbine blades (which promptly deform five or ten times the tolerance when hot) probably omitted.

U.S. AIRCRAFT, produced by huge concentrations of organization, facilities and skilled labor, are projected on a totally different design, production and economic philosophy than that evident in the MIG and its flightmates. That the MIG is passably functional and *expediently improvable* cannot be denied. We do a better job—but let's not be *smug* about it and *miss the patent and pregnant point* it emphasizes. Viz:

HIGH PRODUCTION OF FUNCTIONAL FIGHTERS WITH MINIMUM FACILITIES

MIGs are assembled from bits-and-pieces, adapted for component production in "alley shops", or backyards, like they build trailers in California. *A man can carry any structural member.* All parts could be made sub-assembled or assembled in four-car garages. Light trucks and/or pack mules could handle sub-assemblies. Low-skilled labor could, and probably does, do the job, omitting instruments, electronics, etc. Variations in workmanship on different components indicate different sources and inspection. Are the 611 we shot down, a month's or a week's total production?

North American F86 Sabrejet, score vs. MIG—11 to 1.

WHAT *can we learn?* Couldn't our large and small existing U.S. light industry facilities *Volume-produce* packaged, "build-it-yourself" assembly-kits for fighters and missiles, possibly *adhesive fastened* for *decentralized* assembly by our less industrial allies? Could such a spread-the-work and save-the-buck program *beat the Russians at their own game?* Maybe MIGs are *not* built "the hard way" when the World labor-pool is considered.

CASTINGS WILL REPLACE MANY "BIT-PIECES" IN U.S. AIRCRAFT

RESULTS of Government sponsored Casting Design-Process, Research and Development has stimulated increasing interest in utilizing *advanced* casting processes pioneered by General Alloys in aircraft production.

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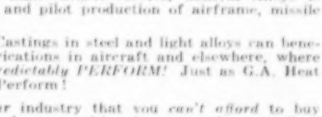

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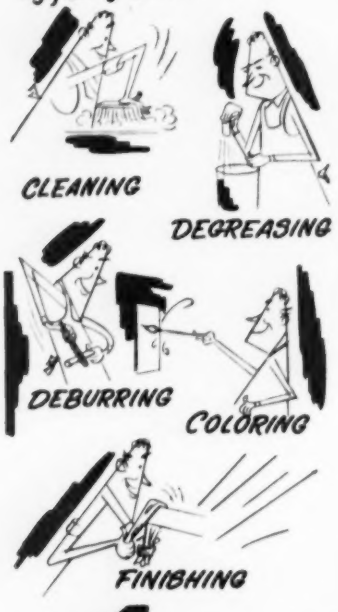

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Silicon Monoxide . . .

(Continued from p. 190)

ing the sample before and after completing the run. In the second method, the entrainment gases were removed from the hot zone through an aperture and cooled, and the condensation product of SiO was collected and weighed. In the weight-loss method large corrections were necessary for silicon monoxide loss by diffusion, but in the collection method the entrained material could be collected separately from deposits formed by diffusion, thus making diffusion corrections unnecessary.

Two tables in the paper show that the weight-loss method was used in the range of 2370 to 2625° F., while the collection method was used between 2730 and 3000° F.

The operating cycle on the runs was conducted with careful precision using the highly purified argon described above. The charge of silica and silicon, thoroughly mixed in an agate mortar, was packed in a small aluminum boat and placed in the furnace tube. The tube was evacuated during the first stages of heating to remove as much moisture as possible. When the furnace temperature reached 570° F., argon gas was admitted. Heating was conducted for several hours in a very slow argon stream to dry out the refractory in the system as thoroughly as possible. Some silicon monoxide was produced during this preliminary heating, and condensed as a brown mass in the cooler parts of the furnace. The furnace was then cooled almost to room temperature with a very slow argon stream and a quantitative run was begun.

After these preliminaries, a run lasting from 2 to 9 hr. was conducted and several runs were made on the same batch at the same temperature in order to get a consistent result. At the end of the run the boat and its contents were transferred to a desiccator and weighed at room temperature. The loss in weight was calculated as silicon monoxide. The tabulation of the results of this weight-loss method indicated a partial pressure of 2.1 mm. for SiO at 2370° F. and 9.1 mm. at 2625° F. The value of the free energy ΔG° was calculated at 37.0 kg-cal. at 2370° F. and 30.2 at 2625° F.

(Continued on p. 202)

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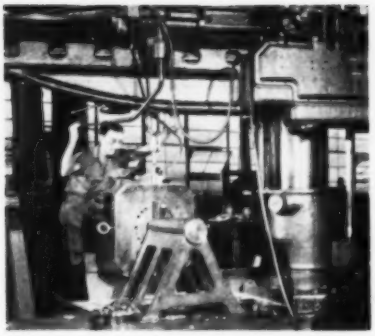

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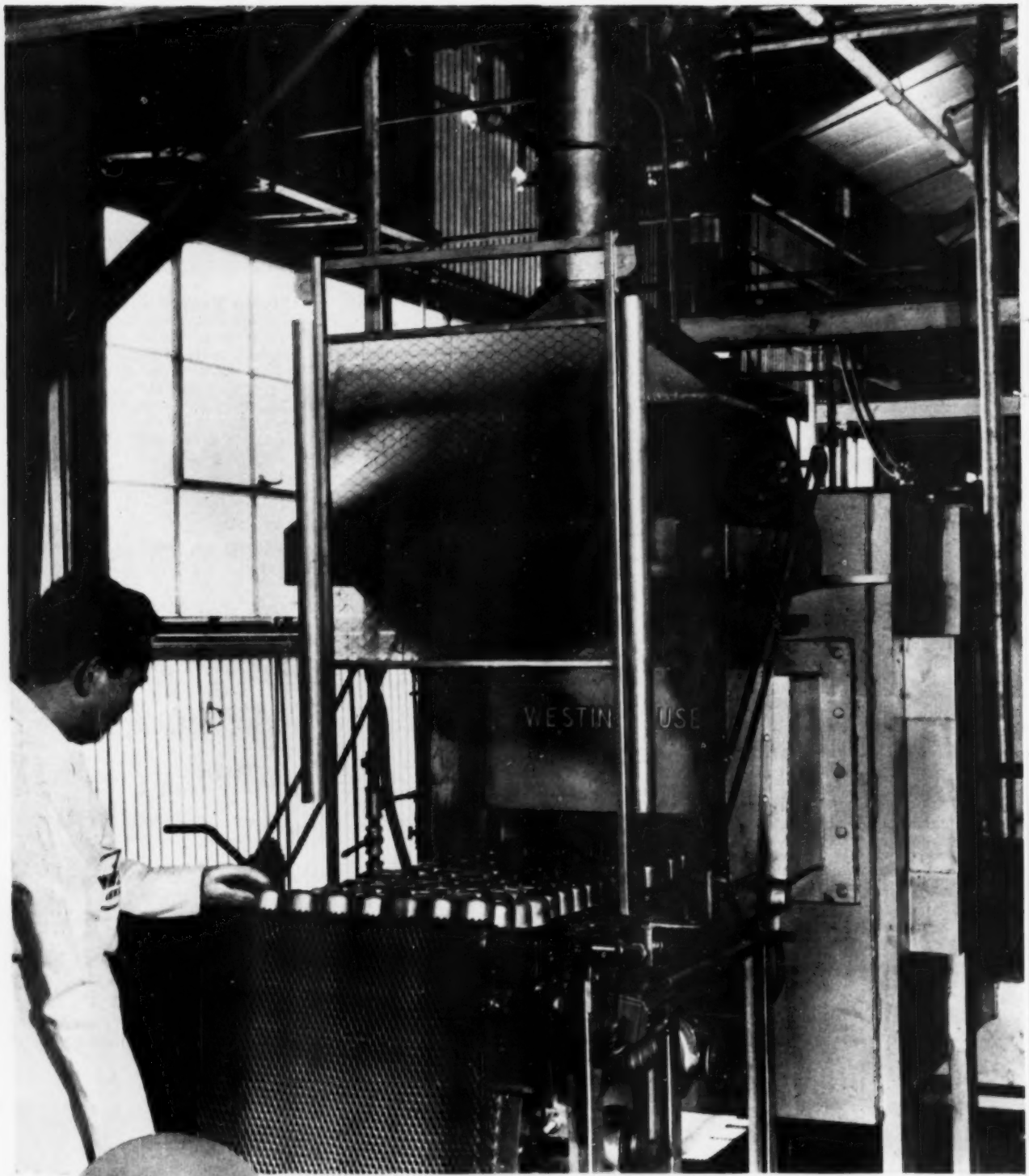

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. . . says Kwikset Locks, Inc.

As the largest producer of custom-molded powdered metal parts west of the Mississippi, Kwikset Locks, Inc., of Anaheim, California, has this to say about its Westinghouse Sintering Furnace:

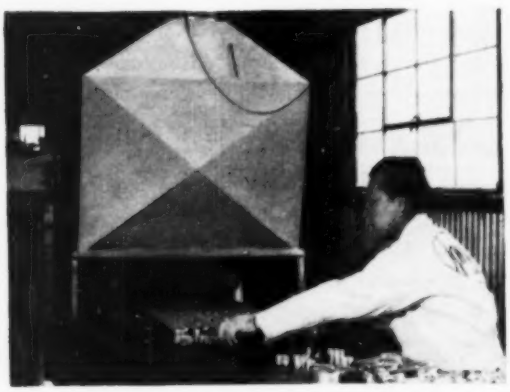
"We chose a Westinghouse Electric Belt Conveyor Furnace when desiring four times the production capacity formerly available. We now enjoy the desired protective atmosphere needed for top-quality control, gain excellent temperature control and response, and take advantage of fast Westinghouse engineering and repair service. We have found, through experience, that Westinghouse Furnaces are easy to operate.

"Our principal operation is sintering brass components for our residential and commercial lock sets. These parts were formerly machined from bar stock, precision cast or stamped. By converting to the sintering process with a Westinghouse Electric Belt Conveyor Furnace, we have eliminated scrap and machine finishing . . . thus increasing production and reducing costs."

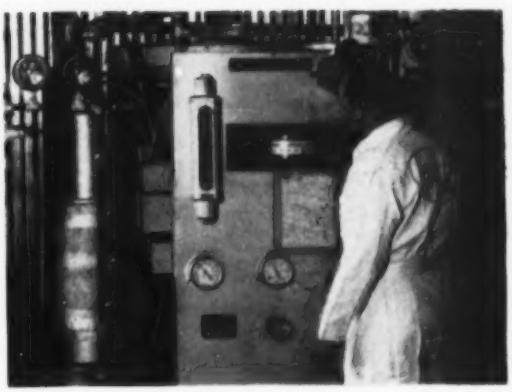
Why not investigate Westinghouse Heat-Treating Furnaces for your plant? A complete line covering every heat-treating job is available. Write for free book *Harnessing Heat* (B-5459). Westinghouse Electric Corporation, Industrial Heating Department, Meadville, Pa. J-10412

YOU CAN BE SURE... IF IT'S

Westinghouse



The above shows the "briquettes" after they have left the cooling chamber where they have been cooled below oxidizing temperature. If unusually close tolerances are not involved, the pieces are used as sintered.



Shown above is the Westinghouse Ammogas® Atmosphere Generator (1500 cfh, 1850° F. max.) that gives Kwikset Locks, Inc., the desired atmosphere for top-quality control.

Announcing . . .

Metals Handbook Supplement

A "1954 Supplement" to the 1948 edition of A.S.M. Metals Handbook will be ready for distribution by the American Society for Metals during the summer. The Supplement will contain some 24 sections adding to the major subdivisions of the 1948 Handbook and also providing new articles on certain subjects never before dealt with in the Handbook. The Supplement will contain about 200 pages similar in size and style to the pages in the present Handbook—that is, it will be a reference volume of about 300,000 words.

In order that A.S.M. members may receive this additional Handbook material as promptly as possible and at no charge, the entire 200-page supplement will be incorporated in an extra (13th) issue of the Society's monthly magazine, *Metal Progress*. This "Bonus Issue" of *Metal Progress* will be off the press at mid-year and will be mailed to all members of the Society. Members need not order the publication—it will be sent to all at no charge, as soon as available. The entire mid-year issue will be devoted to these Metals Handbook articles and will be circulated to all A.S.M. members and *Metal Progress* subscribers in addition to the 12 regular issues.

For the benefit of those members who may prefer to have the 1954 Handbook Supplement in bound form, it will be issued as a separate hard-cover volume at a nominal charge. A later announcement will give a definite price and instructions for ordering the bound supplement if desired.

It should be noted that the 1948 edition of the Handbook is *not* being replaced, but merely supplemented, and the 1948 volume should *not* be returned to headquarters when the supplement is received.

The material to be included in this supplement can be subdivided roughly into three categories, namely—metals, processes and design. Information in the 1948 Handbook will be supplemented with new material on the following metals: alloy steel, stainless steel, toolsteel, ductile iron, heat resisting alloys, aluminum, copper, magnesium, and titanium. Under processes, new and revised information will be provided on forming, machining, heat treating, steel production, cleaning and finishing, mechanical testing, nondestructive inspection, metallography. Design problems will be covered in articles on engine wear, stress concentration, brazed joints, shot peening, powder metal parts, design of castings.

All of the material on these 24 subjects is being prepared by 24 technical committees of the A.S.M., under the general direction of the Metals Handbook Committee. A total of 154 top engineers and metallurgists are contributing through these committee activities. Each article will be the product of a group of experts working together to give a balanced view of the best current practices.

The 1954 Metals Handbook Supplement is another service to members of

American Society for Metals

7301 Euclid Ave. Cleveland 3, Ohio

TO EACH HIS OWN

A Fable

(our apologies to Aesop)

with added comments on Grinding Oils

A dog, a cat and a horse lived and worked on a farm together, each doing his own job well. However, each thought the other had an easier job . . . and one day they decided to change.

The cat became a watchdog, but failed to scare any thieves away; the horse tried to catch mice and kicked out the side of the barn; the dog almost had a sunstroke trying to pull the plow and wagon. Each quickly became tired and discouraged. All were most happy to return to the work they were able to do best.

The Comments:

THERE are three types of grinding fluids . . . "hard" for grinding soft, tough stringy materials; "soft" for grinding materials of high hardness; and "medium" for use in grinding the wide range of average work . . . and like the dog, the cat and the horse, each works best at its own job and not one is good for every job.

Experience has led D. A. Stuart Oil Co. to develop grinding fluids to meet the various conditions and problems *you* may encounter. Better wheel form and longer wheel life, better surface finish and closer tolerance control are some of the results you may expect when using the *right* Stuart grinding fluid for the job. And to assist in selecting the proper grinding fluid for your particular needs is your Stuart Service Engineer. Fill out the coupon below today for a Stuart Precision Grinding Oils Bulletin . . . and be sure to ask to have a Stuart Engineer call.

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SUPER-ALLOY Ring after 162 HOURS

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HEAT-RESISTANT, HIGH-STRENGTH, LIGHTWEIGHT CEMENTED TITANIUM CARBIDE

3-45

SALES OFFICES IN PRINCIPAL CITIES

Silicon Monoxide . . .

(Starts on p. 188)

The second phase of this research involved a study of the reaction

$$SiO_2 + H_2 \leftrightarrows SiO + H_2O.$$

The equilibrium constant for this reaction is

$$K_p = p_{H_2O} \frac{p_{SiO}}{p_{H_2O}}$$

However, if the starting materials are pure and dry, ^pH_2O and ^pSiO are necessarily identical, and the equilibrium constant may be written:

$$K_p = \frac{p^2_{H_2O}}{p_{H_2}}$$

Using this expression as a measure of the reaction, an accurate determination of the percentage of water vapor and hydrogen in the effluent gases enabled a ready calculation of the amount of silicon monoxide produced. For this purpose the composition of the gases leaving the reaction zone was measured accurately and continually by the thermal conductivity method. A detailed description of this apparatus and its calibration is contained in the paper.

In this part of the study, carefully purified and dried hydrogen gas was passed over powdered quartz which had been placed in a sintered alumina boat. Using the same molybdenum-wound furnace, measurements of the extent of this reaction were made in the temperature range 2240 to 3005° F. The percentage of water vapor and hydrogen in the gas, the value of K_p and the value of ΔG^o were determined.

The results of the two investigations are summarized and checked by a combination of the free energy changes in the various reactions involved. These are as follows:

$SiO_2 + Si = 2SiO$
$\Delta G^o = 117.1 - 0.0509T$

$2H_2 + O_2 = 2H_2O$
$\Delta G^o = -118.0 + 0.0268T$

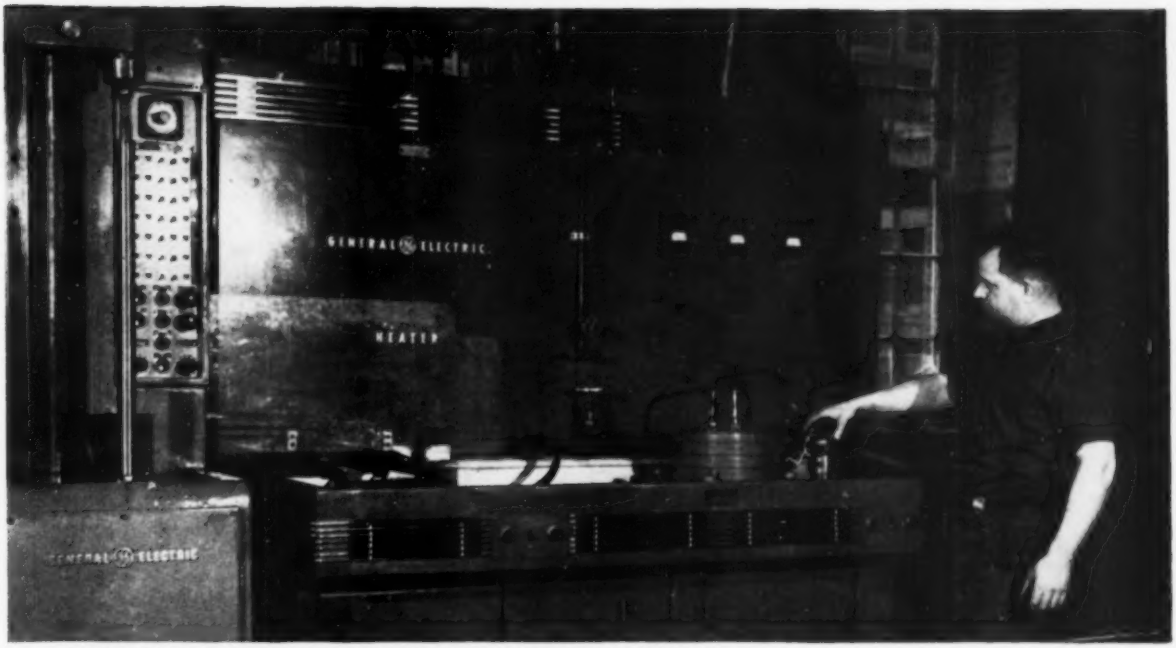
$Si + O_2 = SiO_2$
$\Delta G^o = -208.3 + 0.0433T$

$SiO_2 + H_2 = SiO + H_2O$
$\Delta G^o = 103.7 - 0.0337T$

The authors deduce the following expression for the standard free energy of the formation of gaseous silicon monoxide from silicon and oxygen.

$2Si + O_2 \leftrightarrows 2SiO;$
$\Delta G^o = -91.2 - 0.0076T$

E. C. Wright



INDUCTION HARDENING TEXTILE-MACHINE PARTS AT WHITIN MACHINE CO.

Hardening Output Increased Ten Times With G-E Induction Heaters

"Since changing to General Electric induction heaters for hardening twister rolls we've increased our hardening output ten times and improved product quality!" reports Arno Wagner, heating engineer, Whitin Machine Co., Whitinville, Mass.

When using cyanide furnaces for hardening, it took Whitin 3½ hours to harden only 11 rolls. Now, by applying selective G-E induction heat, Whitin hardens over 35 rolls per hour! Because parts require no expensive preparation for heating—necessary with furnace hardening—Whitin has reduced costs significantly. Hardness tests show induction-hardened rolls to be stronger and of more uniform hardness.

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Included in Whitin's heating operation are one 50-kw and three 20-kw G-E heaters. Used primarily for hardening over 500 parts for textile machines, these versatile heaters are also applied for annealing, soft soldering, and silver soldering. In each case, substantial savings in time and money have resulted.

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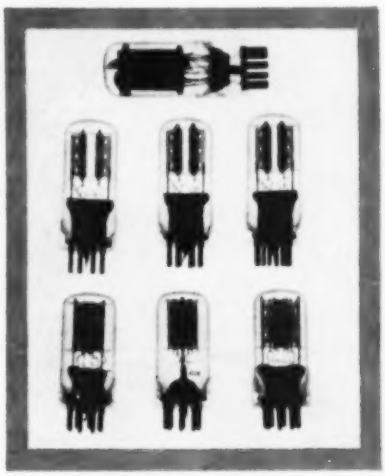
one minute
is all it takes to get finished, dry radiographs

Subject: **IGNITION CABLE ELBOW**
(Ignition cable elbows filled with insulating sealing compound.)
Objective: To confirm winding spacing alignment of center wire.
Disclosed: Gas bubbles in elbows where compound failed to fill.

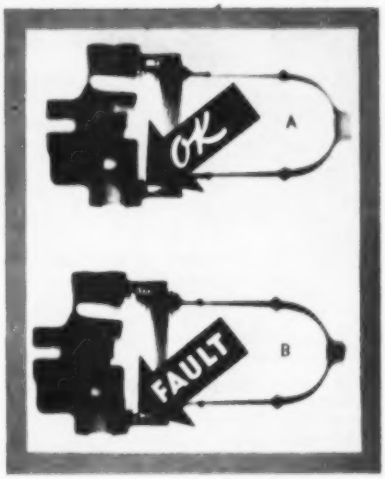
* NOTE: Reduction to 1/5 size, combined with image decay incident to the printing process, seriously degrades in these miniature reproductions the fine detail of the 10" x 10" originals.

like



Subject: **ELECTRONIC TUBES**
Objective: To confirm alignment and spacing of elements.
Disclosed: All elements correctly oriented.

these*



Subject: **CAST ALUMINUM GASOLINE FILTER**
Objective: To confirm correct placement of gasket after completion of assembly.
Disclosed: (A) Correct assembly (B) Fractured gasket slipped out of place.

with

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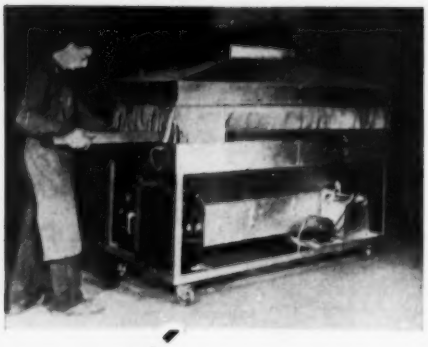

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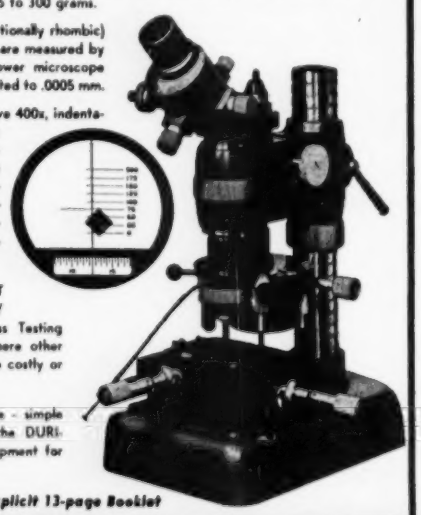

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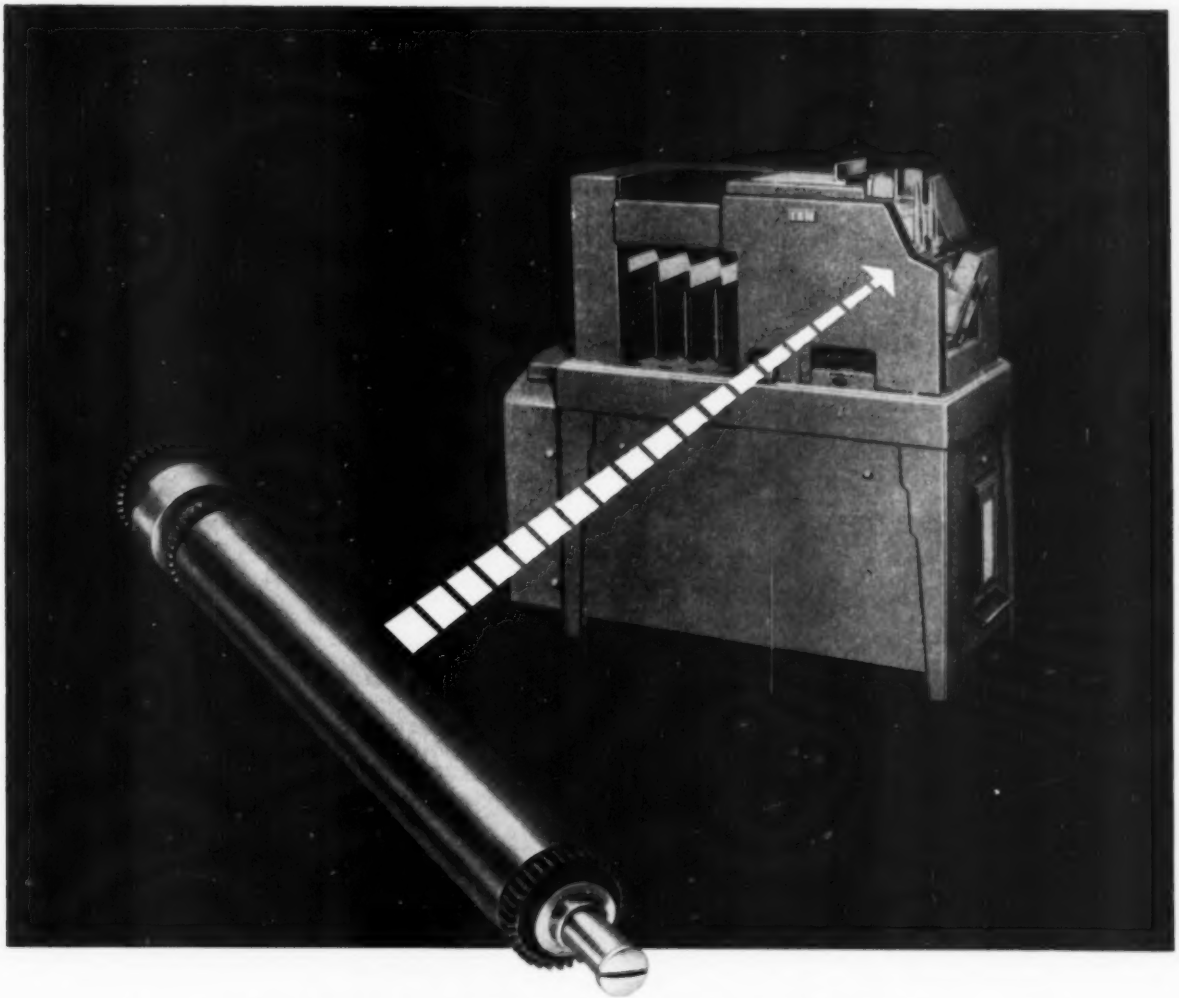

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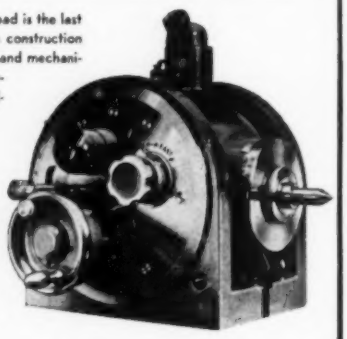

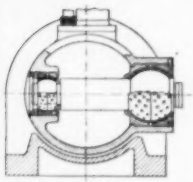

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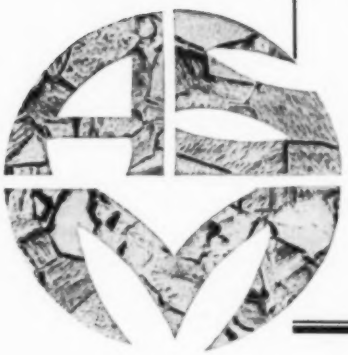

Invitation to Entrants

9th Metallographic Exhibit

Entries are invited in the 9th ⊕ Metallographic Exhibit, to be held at the National Metal Exposition in Chicago the week of Nov. 1 through 5, 1954. Entries will be displayed to good advantage and awards will be given for the best micrographs as decided by a committee of judges.

Classifications of Micros

1. Toolsteels and tool materials
2. Stainless steels and heat resisting alloys
3. Other steels and irons, cast or wrought
4. Aluminum, magnesium, beryllium, titanium and their alloys
5. Copper, nickel, zinc, lead and their alloys
6. Metals and alloys not otherwise classified
7. Series showing transitions or changes during processing
8. Welds and other joining methods
9. Surface phenomena
10. Results by unconventional techniques (other than electron micrographs)
11. Slags, inclusions, refractories, cermets

Awards and Other Information

A committee of judges will be appointed by the Metal Congress management which will award a First Prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded (with appropriate medals) to other photographs which, in the opinion of the judges, closely approach the winner in excellence. A Grand Prize, in the form of an engrossed certificate and a money award of $100, will also be awarded the exhibitor whose work is adjudged best in the show, and his exhibit shall become the property of the American Society for Metals for preservation and display in the Society's National headquarters in Cleveland.

All photographs may be retained by the Society for one year and placed in a traveling exhibit to the various Chapters. They will be returned to the owners in May 1955 if so desired.

Rules for Entrants

Work which has appeared in previous metallographic exhibits held by the American Society for Metals is unacceptable. Photographic prints shall be mounted on stiff cardboard; maximum dimensions should be limited to 15 by 22 in. Heavy, solid frames are not permissible because of difficulties in mounting the exhibit. Entries should carry a label on the face of the mount giving:

Classification of entry
Material, etchant, magnification
Any special information as desired

The name, company affiliation and postal address of the exhibitor should be placed on the BACK of the mount.

Transparencies or other items to be viewed by transmitted light must be mounted on light-tight boxes wired for plugging into lighting circuit, and built so they can be fixed to the wall.

Entrants living outside the U.S.A. should send their micrographs by first-class letter mail endorsed "Photo for Exhibition—May be opened for customs inspection." To be acceptable as first-class mail the package should measure no more than 35 x 45 cm. (14 x 18 in.)

Exhibits must be delivered before Oct. 15, 1954, either by prepaid express, registered parcel post or first-class letter mail, addressed to:

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International Amphitheater
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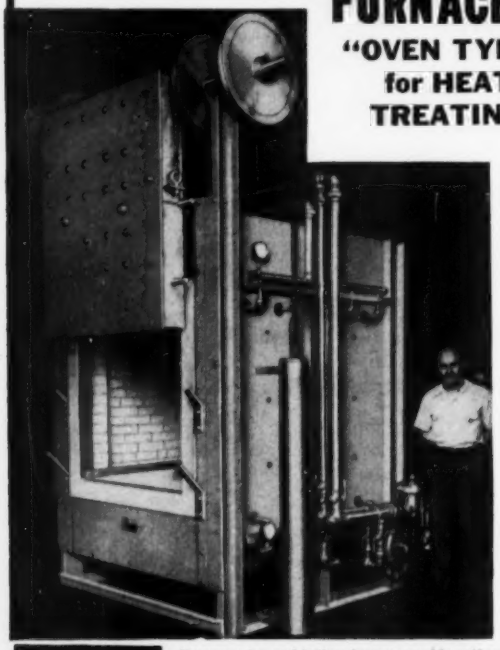

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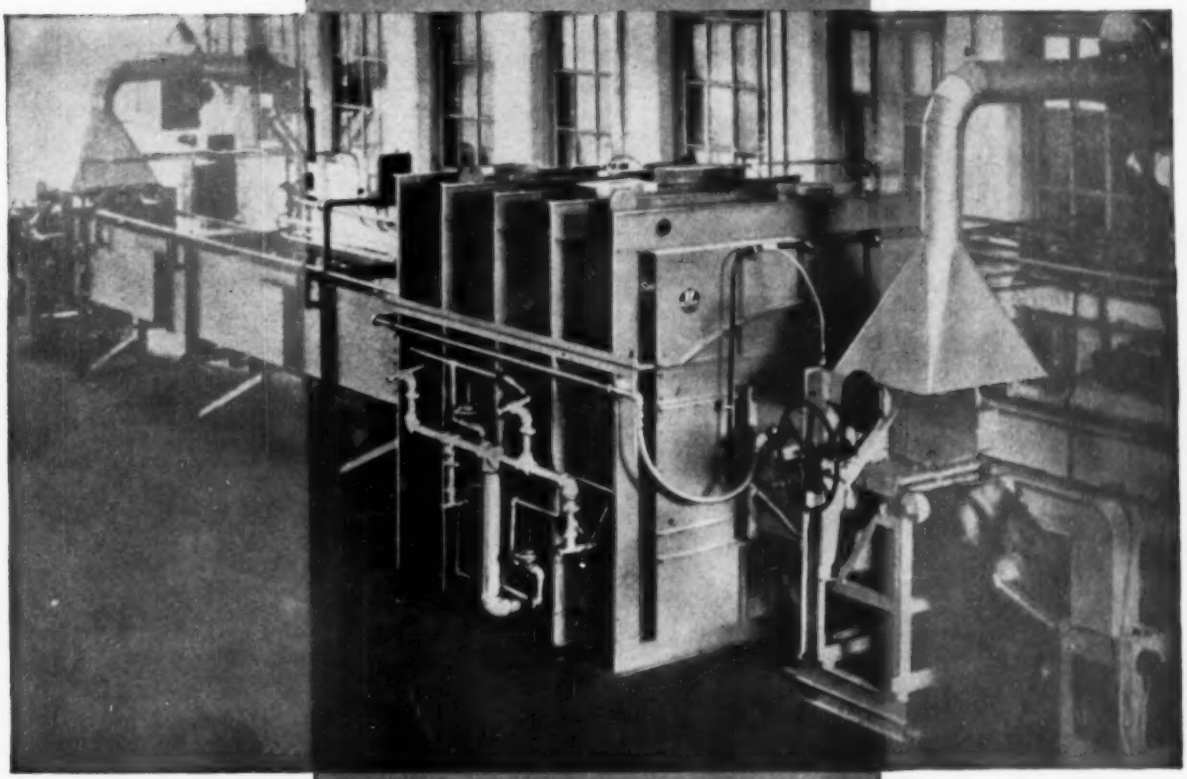

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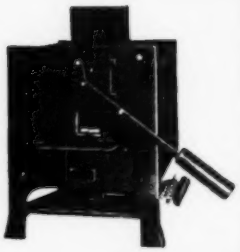

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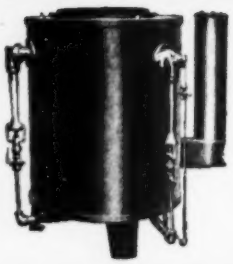

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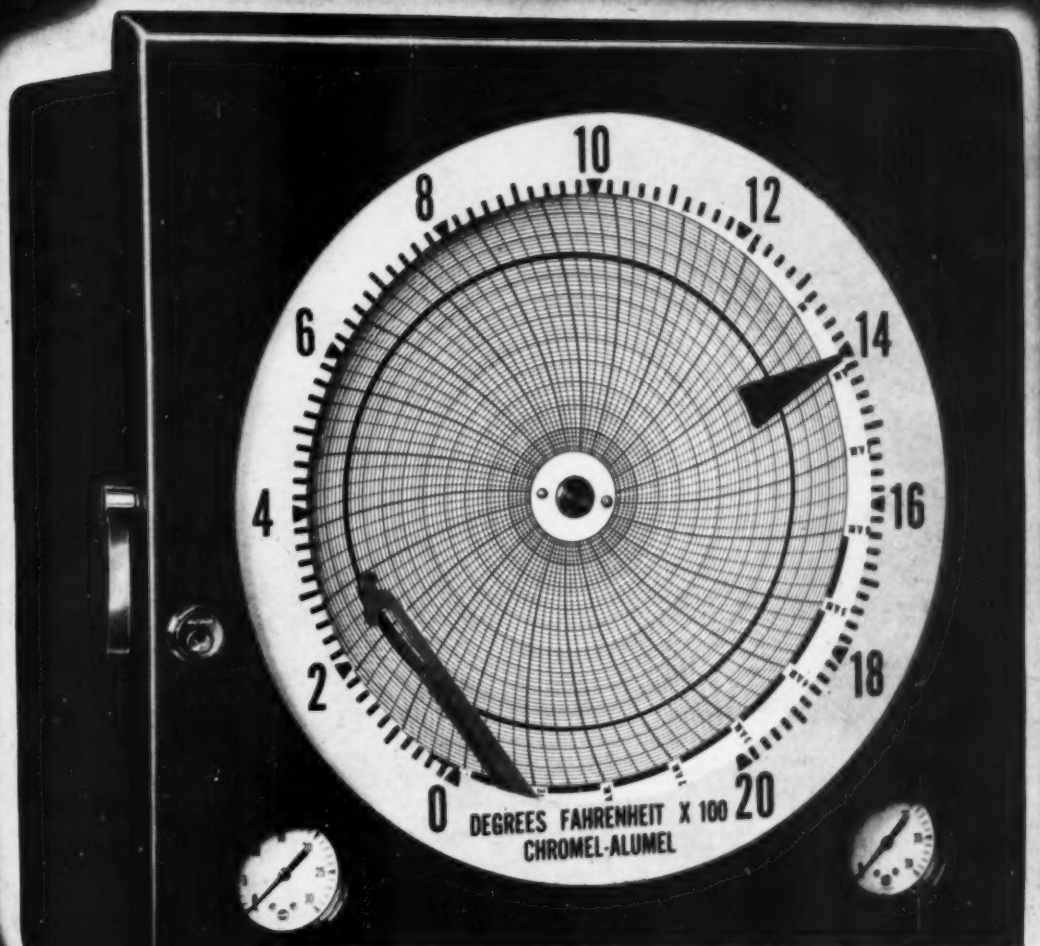

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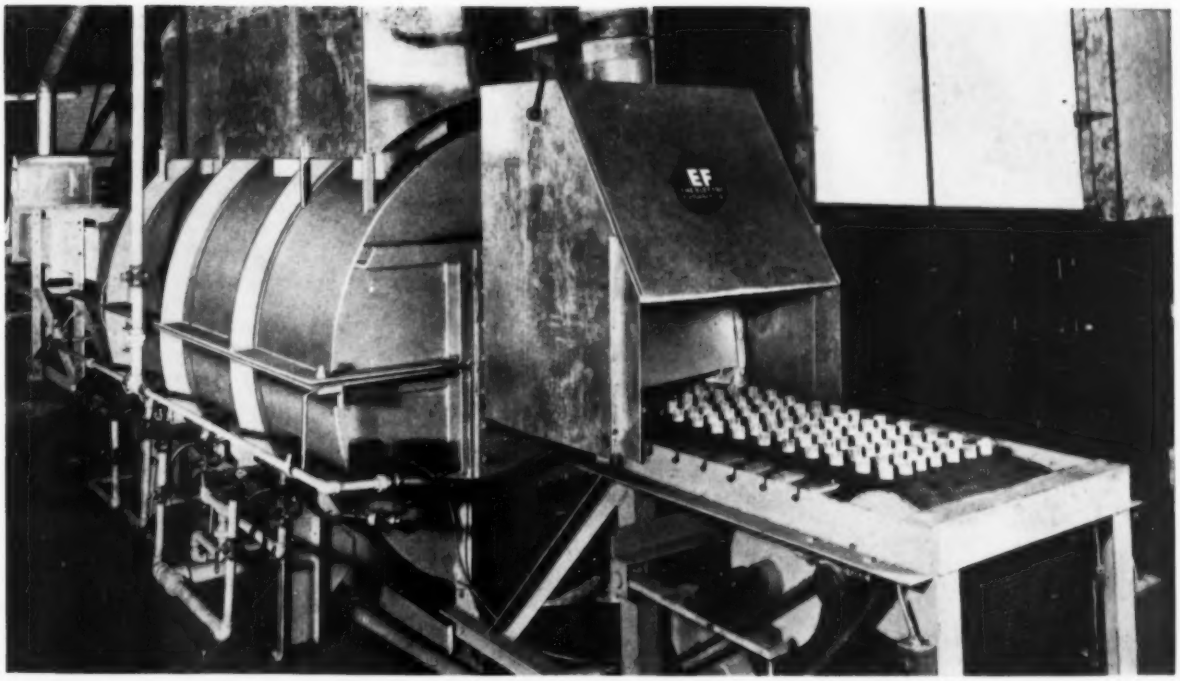

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